35 centavos a copy
₱3.00 a year
(10 numbers)

The Philippine Agriculturist

Foreign subscription
$2.00 a year
(U. S. currency)

Entered at the Post-Office at Los Baños, Laguna, as second-class mail-matter

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VOL. VIII DECEMBER, 1919 No. 5.

A REVIEW OF THE RICE INVESTIGATIONS AT THE COLLEGE OF AGRICULTURE[1]

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The study of rice in the College of Agriculture began soon after the establishment of the institution in 1909. So the investigations on the most important cereal of the Philippines reviewed in this paper have been carried on for nearly a decade. All these rice studies, including mere observations as well as actual field cultures and other experiments, have involved a gradually increasing area of land and a fast increasing number of varieties. Of native varieties, no less than 814 have been studied in one way or another, while 46 foreign varieties have been imported. Since rice work in the College has already outgrown the area of land that can be used for it, the investigations of a number of important phases that have been started have either been reduced or entirely suspended. Some of the projects that could not be continued this year on account of lack of land are the multiplication and commercialization of a good quantity of pedigree seed, the planting in row tests of seeds from a number of selected mother plants, and the planting in common cultures of a number of rice varieties for initial selection for different characters. Nearly all rice projects under way have been hampered by lack of sufficient land and labor. It is safe to say that, were land available, twice the present area devoted to rice could have been used merely for the continuation of work already started. Any delay in the acquiring of additional land for the Experiment Station will mean a serious delay in the progress of the most important and essential rice investigations in the Philippines.

[1] Experiment Station contribution, No. 24.

There have been fifty-five separate studies made in the College, twenty of which have already produced results and have been reported. (There are appended to this report lists of rice projects which have either been reported or are under way, and lists of those planned for the immediate future.) These experiments may be classified under the following divisions:

Introduction of Foreign Varieties.
Study of Varieties.
Study of Cultural and Other Factors.
Rice Farm Management.
Rice Breeding, Including Selection.
Rice in Animal Husbandry.
Diseases and Pests and their Control.

INTRODUCTION OF FOREIGN VARIETIES

Since March 13, 1913, when the first importation of foreign rice was made, the College of Agriculture has obtained seeds of forty-six rice varieties. The seeds were secured from: Bombay, India; California, United States; Batavia, Java; Formosa; and Portuguese India. The latest importation, consisting of thirty-seven varieties, came from Portugucee India. As only one planting of these has been made, little can be reported at present regarding them. But they seem to be early maturing varieties; they apparently do better under lowland conditions than under upland; and they do not appear to be uniform as to time of maturity. The varieties showed a very marked tendency to tiller. In their first year in the College they were severely attacked by *Leptocoriza acuta* Thumb.

STUDY OF VARIETIES

It is believed, generally, that there are no less than a thousand varieties of rice in the Philippines. The yield of a number of these is below the average, while many give very high yields. The elimination of the varieties giving low yields and the planting of only those giving highest yields will raise very materially the average yield of rice per hectare. This fact points to the necessity of testing in an adequate way the comparative yields of the different varieties. Before this can be done successfully, it will be necessary to obtain a key for the identification of rice varieties. When such a key has been prepared there will no longer be the great confusion which exists at present regarding the varieties. The Bureau of Agriculture once published what was intended to be a key to classification, but it was not adequate, since it was based almost entirely on grain characters. As it is known that two varieties having the same appearing grains may be very different in regard to their other external characteristics, a satisfactory key for identification must include other external characters besides grain characters. With the idea of obtaining data for this purpose, studies were made by Octubre (1), Dario (4), Manio (2), Torres (3), and Jamias (6), all thesis students. As a result of the studies by these students, a total of 308 varieties have been described. These varieties have come from the provinces of Nueva Ecija, Ilocos Sur, Ilocos Norte, Cagayan, Abra, Batangas and Laguna, and from Portuguese India. The descriptions are based on nearly all external parts of the rice plant. With these descriptions available, it may now be possible to find out whether one variety of rice included in the study appears under different names in different localities, and whether two or more varieties are called by the same name in different places.

The result of the study of external characters of rice would be of more permanent value if it could be shown that the characters involved in the descriptions do not vary with changes of environment. If a certain color, for example, appears in the hull of the grain under a certain set of conditions and does not appear under another, this color is of no value in classification. A piece of work has been started, under the writer, by Gregorio Lontoc (7) to determine which of the external characters that are now supposed permanent are variable. Five varieties are being employed in this work.

Although it is realized that well-performed variety tests should be preceded by thorough classification and accompanied by the establishment of standard rice nomenclature, nevertheless, the necessity of obtaining reliable information on the comparative yields, value, and behavior of the rice varieties, as they are now known, can not be overlooked. For this reason, comparative trials of twenty-four varieties have been carried out by Crisostomo (5). As a result of these trials, the comparative yields of all the varieties were determined. Some varieties were found to be decidedly early maturing, while others were late maturing. The general characteristics of the grain were also studied. Selection experiments and other studies in which more than one variety is used, also furnish data on comparative yields of rice varieties, even if such investigations are not performed mainly for this purpose. In Gutierrez's (37) work, for example, it was found that the varieties Iroy and Binalayan yielded decidedly more than Ganado, Binicol, Binangbang, or Diquet a Bolilising. As a continuation of this kind of work, more than 120 varieties have been planted both by thesis students and by the class in Agronomy I under the supervision of Mr. Toribio Vibar (9). For lack of sufficient land this year, each variety can not be planted on as large a plot nor replicated as many times as more reliable results would demand.

In 1918, seeds of a wild rice were sent to the College by Mr. Wester, of the Bureau of Agriculture and Mr. Merrill, Director of the Bureau of Science. They have already gone through their first generation here, and herbarium specimens have been sent to the Bureau of Science for further identification. The planting of this rice will be continued as far as other studies will allow.

EXPERIMENTS ON CULTURAL AND OTHER FACTORS

One of the pieces of rice investigation undertaken during the early days of the College was by Roxas; it dealt with mineral stimulants (10). It has been found that by the use of stimulants the yield of certain crops has been increased. There is a rather general belief, for example, that copper in Bordeaux mixture stimulates the growth of the potato crop and increases its yield, thereby assuming a double rôle of fungicide and stimulant. Roxas attempted to determine in pot cultures the approximate optimum concentration of several stimulants for rice. He reported that the following salts had a favorable effect on the growth of rice: Fe-powder, sulphates of Mn, Fe, and Zn at M/1000 concentration and of Ni at M/5000; $Co(NO_3)_2$ at M/10000; $HgCl_2$ at M/50000; $Na_2BO_4O_7$ at M/100000; and a large quantity of $Al_2(SO_4)_3$ also stimulated rice growth. On the other hand, M/100 $Na_2BO_4O_7$, M/100 $FeCl_3$ and $CuSO_4$ injured the rice plant.

A feature that is of even more importance than the effect of stimulants upon growth of rice, is the effect of commercial and natural, or manurial fertilizers. While the use of fertilizers in definite combinations and amounts has proved a

profitable farm pratice with certain farm crops in many countries, it can not as yet be said that it would be beneficial to rice production in the Philippines. The problem of fertilizers for rice needs a great deal of investigation before any very definite or valuable conclusions can be reached. The problem should, therefore, be studied from several different points of view. The most fundamental of these is the salt requirement of the plant, and this is being studied in both pot and solution cultures. The study made by Espino [20] in Johns Hopkins University showed that during the early growth and development of rice plants, belonging to a Japanese variety (Wateribune) from the Louisiana Experiment Station, the three-salt solution found by Shive to be very satisfactory for the growth of wheat, was unsuitable for rice. With the addition of $(NH_4)_2SO_4$ to this solution and with an osmotic concentration not exceeding $\frac{1}{2}$ atmosphere, rice grew very luxuriantly. With the substitution of $Ca(H_2PO_4)_2$ for $Ca(NO_3)_2$ in the previous solution, the young plants grew well during the first ten days; but, later on, the leaves exhibited some injury, indicating that (NO_3) or $Ca(NO_3)_2$ was essential with the ammonium sulphate and other salts, for the best development of the young plant. It was found in this four-salt solution that the proportion of K_2HPO_4 to $Ca(NO_3)_2$ to $(NH_4)_2SO_4$ to $MgSO_4$ was 1 : 1 : 1 or 2 : 4 or 5.

Physiological tests in the College, under the direction of Trelease, have dealt with the growth of rice in soil cultures when the three very important elements, phosphorus, potassium, and nitrogen, are added in various proportions [18]. These elements were supplied by means of three common fertilizer salts: primary calcium phosphate, potassium sulphate, and ammonium sulphate. Thirty-six sets of proportions of three salts were employed; thus tests were made with all possible sets of proportions of the three elements when each element was varied by increments of one-tenth of the total salt-content, which was the same in each set. Under the conditions of these tests it was found possible to increase greatly the growth when the proper fertilizer mixture was employed; this increase is shown by the fact that the control culture, which was without fertilizer, gave only about one-fifth of the top and grain yields obtained with the best fertilizer mixtures. Another series of experiments, in which four salts supplying all the mineral elements essential to plant growth were used, dealt with the optimal proportions of these salts. This experiment has in general confirmed the results obtained in other tests here referred to, and also served to strengthen the general idea arrived at by earlier workers, that it is better to apply an ammonium salt to the soil rather than a nitrate as a fertilizer for rice when grown under "lowland" conditions. Experiments of a similar nature are now being continued. Dr. Trelease states that many problems must be investigated before a satisfactory interpretation of the salt nutrition of this plant may be made, since the plant and soil in which it grows form an exceedingly complex chemical and physical system in which the processes are determined by many variable conditions; and that the development of a scientific basis for agriculture requires careful investigation of the general conditions determining the rates of processes that take place in this system, and proper fertilizer practice must depend upon a knowledge of these principles. In the tests thus far made pot cultures, containing about 20 kilograms of soil, have been employed; but it is planned to extend the work to include experiments under natural field conditions. Dr. Trelease has assigned to two thesis students the following problems: First, the effect of different concen-

trations and proportions of potassium sulphate, primary calcium phosphate, and ammonium sulphate upon the growth and yield of rice in pot cultures (31); and, second, the growth of rice in pot cultures containing potassium sulphate, primary calcium phosphate, and ammonium sulphate, and the effects of replacing ammonium sulphate with sodium nitrate, calcium nitrate, and ammonium nitrate (32). A study along this line, in the early days of the College by Zamora, showed that rice plants grown in a soil mixture of two parts loam and one part sand responded to fertilizers in better growth and higher production of grain (11).

The problem of fertilizer requirements has also been approached in a more direct way in this College in the studies made by Balangue and by Goco. Balangue (13) attempted to determine whether the farmers could, by a simple system of fertilization, employ with profit the manures that are at present going to waste in different localities. Besides natural fertilizers, Balangue also used commercial fertilizers. Goco (17) tried to determine the advantages to be derived from application of fertilizer, combined with selection. The results of these two workers showed that it was profitable to use horse manure and ash, either singly or in combination, and that "run-down" fields might be improved by proper application of lime. It was also shown very clearly that a fertilizer formula may apply to one field and may not to another. This supported what is already generally considered to be a fact, that the response that a certain crop may make to a certain fertilizer or combination of fertilizers depends to a great extent on the conditions of the soil. It follows, then, that each different soil region must determine for itself, by experiments, the system of fertilizer practice that is most profitable for that region. Goco's work, particularly, shows that the yield obtained through application of fertilizer may be increased by the use of selected seed.

The investigations on the relation between rice plant and soil substances have not been limited to a study of only the beneficial substances in the soil. It seems to have been the experience of rice planters that the best growth of the rice plant cannot be obtained in soil previously occupied by cogon (*Imperata cylindrica*). In an attempt to determine what the cause of this injury might be, Villegas (12) grew rice plants in soils watered with solutions leached from soil in which cogon was growing, and also with solutions leached from soil in which there were bamboo plants. While the results of this work have not thrown light on the nature of the factors causing the injury, it was found that cogon soil and bamboo soil contained a substance or substances injurious to the growth of rice in acid media. It is not known, however, whether the same injury would obtain in media which are alkaline.

Other crop factors that have recently been studied are those of water and climate. Results of students in plant physiology tend to confirm the belief that most rice varieties usually grow better under lowland conditions than under upland, and that even upland varieties yield more heavily under lowland than under upland conditions (19). In this work, varieties Inintiw (lowland) and Nagdami (upland), were planted under lowland conditions with the result that both gave satisfactory growths. But, when they were planted under upland conditions, Inintiw gave absolutely negative results while Nagdami gave only fair. The work performed by Peralta (14) was on the relation of climatic conditions to the vegetative growth and seed production of rice. This study involved only one variety, Inintiw. The grain yield of this variety was found

highest during the season of high evaporation and lowest during the season of low evaporation. It was also found that in the College locality, Inintiw gave good returns both in straw and grain when planted during the months of May, June, and July and not so good a return when planted during the months of November and December. Low temperature during the first months of growth induced early maturity of this rice. Romero (38) in his selection work found that the period from August to December was not the best season for raising Binangbang, Ganado, Iroy, Binalayan and Diquet a Bolilising. The determination of the best months to plant rice is being continued by the Agronomy I students under Mr. Vibar (27).

A great part of experimental activity of the Agronomy Department is devoted, at present, to a preliminary study of what might be collectively called *factors of cultivation.* This study includes methods of handling the crop from seeding to harvest. In the choice of seed, for example, we are interested in knowing whether in a given amount of rice seed the larger or heavier seeds would always produce higher yielding plants than the smaller or lighter seeds. The relation of size or weight of seed to yield has been investigated both in the United States and Canada, for cereals especially, for the last twenty-six years, and the weight of evidence obtained from numerous investigations is clearly against the old belief that larger and heavier seeds of cereals were better in yielding power than the smaller and lighter ones. What has been known as the "pure line theory" is also in accord with such results. So it would seem that there is no necessity for a similar investigation for rice. But, in the absence of any definite data obtained under Philippine conditions, we would not be in a position to either recommend or condemn the practice of selecting seed merely by size and weight. Isidoro Collado (21) of the Plant Breeding Division is studying the relative yield value of large and small and heavy and light seeds. He is using the varieties Inintiw and Binicol and has both pot and plot cultures. Several methods are being employed in separating the larger or heavier seeds from the smaller or lighter ones. For pot cultures the different kinds of seeds are hand-picked. For field plantings, seeds are graded by gravity methods.

The relative yield value of seeds on the different culms of individual rice plants should be demonstrated. It is sometimes assumed that in each rice plant the best culm bears the best yielding grains. Such an assumption appears to be without genetic foundation. But a practical test of this question has seemed advisable. And the Plant Breeding Division has, therefore, made plantings of rice seeds from the better and the poorer culms of separate plants to obtain data on this question (49).

Another seed problem is connected with dormancy in rice seed. This year several farmers in the vicinity of the College have tried to exchange their newly harvested seeds for the Agronomy Department's older ones. The farmers claim that newer seeds take a longer time to germinate and have a poorer germination than somewhat older seeds. The writer is conducting an investigation along this line. It is desired to determine whether there is dormancy in rice seed, and, if there is, the length of period in different varieties. Should such a phenomenon be found effort will be made to discover some means by which the period of dormancy may be either removed or shortened (51).

The age at which to transplant rice ([25]), the distance ([33]), rate ([24]), and method of planting (drilling or broadcasting) ([26]), and the most economical and profitable methods of irrigating ([29]) and harvesting ([22]) rice are being investigated in this College. The cultural methods employed by farmers outside the College are also under investigation ([28]). This consists not only in the observation of the methods practiced outside, but also in actual tests of these in the College. It is known, for example, that rice growers of Negros, Iloilo, and Capiz plant rice and corn in the same field, and claim that higher yields of rice and corn are obtained in this way than in simple cropping. Mr. José P. Esguerra ([15]) tried to determine the effect of mixed cropping on yield; he used the upland rice variety Binagongtao and the common native yellow flint variety of corn. While the results obtained were not entirely conclusive, there seemed to be an indication that the claim in question is justified. The study of structure of the root of rice seedlings has been undertaken by Mr. Eduardo Quisumbing ([30]). The results of this study will be of botanical but not yet of economic importance.

FARM MANAGEMENT AND RURAL ECONOMICS

Three papers have been presented and one is now in preparation which involve problems of farm management as well as the economic status of rice production. The first of these papers was by Aurelio in 1915 on the cost of production of rice by Philippine methods ([33]). The importance of this study may be realized if it is stated that at present it is not definitely known whether rice production in the Philippines is a paying or a losing business. Aurelio's study covered a number of fields in Calamba, Los Baños, and Calauang in Laguna province, as well as fields in Iloilo and Capiz. Through correspondence with planters of Occidental Negros and Tarlac, data were also secured from those provinces. As a result of his investigations Aurelio found that the cost of production of rice was ₱1.56 per cavan; that in tenant work the profit went to the land owner, or in case of double tenantry, the profit went to the land owner and head tenant; and that the exorbitant rates of interest imposed by the money lender on the small farmer increased greatly the cost of rice production. From these results Aurelio concluded further that for a small farmer to grow rice profitably, under the present system, the farmer should be the absolute owner of the land; and that, even then, rice growing may be profitable only when the farm is well located with regard to water supply. To save the small farmers from the injustice of the usurious land owners, the establishment of rural credit societies was deemed to be a necessity.

A second thesis, recently completed, dealing with farm management and rural economics, is that of Mr. Rufino Isidro ([34]). Concerning this work, Professor Hester, of the Department of Economics, made the following statement:

"Mr. Isidro's thesis has been evolved from so limited a survey that it would be injudicious to credit his conclusions with generality. The evidence of the data is, however, that in the barrios of Anos and Maahas, Municipality of Los Baños, neither the tenants' labor income nor the landlord's interest on investment was high enough to make rice growing an alluring proposition.

"The thesis stands as a pattern for tabulation and computation of production costs and distribution of income. If funds were available to extend this same form of investigation to one hundred typical units in each rice-producing

district in Luzon, we might then know how high a producers' price would be necessary to insure domestic production of the Philippine supply of this important cereal."

The cropping of upland rice by bullock labor has been studied by Mr. Alfonso de la Paz (35). The object of this work was to determine whether bullock labor can largely replace manual labor in growing upland rice. A substitution of animal labor for manual labor would, it is believed, lessen considerably the cost of rice production. De la Paz found that rice in drilled plots that were cultivated by bullocks was uniform in germination, uniform in stand and in ripening, and gave the greatest production of culms. Such rice was easy to cultivate and to harvest. Compared with broadcasted rice, drilled rice was more resistant to drought. The writer believes, however, that the difference was largely due to cultivation and not to the way in which the rice was planted.

In the "half-weeded" plots, an increase of from 1.8 to 16.08 cavanes per hectare was obtained. In the thoroughly weeded plots, the increase was from 10.85 to 22.42 cavanes per hectare. The cost results in de la Paz work were declared abnormal in certain respects. Despite this, his work has indicated that it costs less to cultivate drilled rice by bullocks than to hand-weed a broadcasted field. The cost of producing a cavan of upland rice was less for drilled rice than for broadcasted or caiñgin-sowed rice, and amounted to ₱3.08. This amount is higher than that found by Aurelio (33) for lowland cultures. However, even if this cost is made lower, after certain corrections are made in de la Paz's method of calculation, it will remain higher than Aurelio's figure.

An economic study now under way is that of Rodolfo Asuncion (36) on the cost of land preparation in the vicinity of Los Baños. While this will apply to the preparation for various crops, it will deal especially with rice. The survey will include a minimum of one hundred units and involve itemized tabulations of labor, implement, and animal costs.

RICE BREEDING, INCLUDING SELECTION

The breeding of rice for increased yield was inaugurated in this College in 1915 when the Agronomy Department made initial selection of mother plants from multiplication cultures of seeds sent here by the Bureau of Agriculture. This beginning involved only upland varieties. The seeds of the selected plants were planted in head-to-row tests by the Agronomy V class in 1915 and repeated in another generation in 1916. The best materials from the last row tests were subsequently multiplied in two successive years by Mr. Ramon Habaluyas (40). With each multiplication planting, a check culture was made consisting of a field with unselected seed of the corresponding variety. In the first year of multiplication, the 17 varieties which were involved in the work all yielded more than their corresponding unselected fields, the increase ranging from 0.44 of a cavan to 16.95 cavanes per hectare. Three of these 17 varieties were again multiplied on still a larger scale the following year, and the results showed increases in favor of the selected strains of four to nine cavanes per hectare. This year (1919) there is no culture of Habaluyas' seed on the College farm. However, one-half cavan seed of each of two superior varieties was given to Mr. Nicasio Villegas of Los Baños for trials in his fields.

Gutierrez (37) started another study of selection, with four Ilocano and two Tagalog varieties. Gutierrez' work was continued by Romero (38) and Mr. Juan B. Cabanos, (39) and at the present time is in the hands of Francisco Bernardo (46). A point worthy of mention in connection with this work is the very small number of mother plants or lines with which the work was begun, and the still smaller number of strains being used at present. The following table will show this point clearly for Gutierrez' work. This decrease did not mean a decrease in the scale of the work, because each strain surviving has occupied an increasing amount of land every year.

Variety name.	Number of mother plants or lines at the beginning.	Number of lines with which the work is being continued.
Ganado	39	6
Iroy	40	8
Binalayan	40	6
Diquet a Bolilising	25	6
Binicol	12	(Discontinued.)
Binangbang	21	4

As a result of this work it was found that selected strains of rice varieties yielded more than unselected strains on farms outside the College, the increase sometimes amounting to 50 per cent. As a further result of the work originally started by Gutierrez, there are now being grown, in either test rows or multiplication fields, thirty strains of five different rice varieties. There also has been available a moderate amount of pedigree seed for outside trials. Mr. Joaquin Gonzalez ('19) has kindly consented to plant in Apalit, Pampanga, selected seeds of seven varieties.

Last year (1918), under the direct supervision of the writer more work than in any previous year was begun in rice yield selection. Approximately 2000 mother plants from 94 varieties were selected. The offspring from these are now growing in test rows. Aside from this breeding work, there are at present three advanced students working on rice selection. Francisco Bernardo (46) is selecting for high yield, Severo Yap (45) for decreasing the time required for maturity, and Anselmo Labrador (44) for increasing the breaking strength of straw. The last two are beginnings of two pieces of work that are not less important than yield selection. In irrigated areas of our rice regions it is believed that the number of crops raised could be materially increased by the use of early maturing strains of the local varieties. In Bohol, for example, only five crops are raised every two years. By the use of early maturing strains it may be possible to raise six crops in two years—i.e., three crops in a year. Yap has included among his seven varieties, two from Bohol. Labrador's work is expected to give preliminary data on the question of whether rice strains exist that are distinct for their high degree of bending strength. Eight varieties are involved in this work. It is assumed that if rice strains are found with stems sufficiently strong to allow the efficient use of machines in harvesting, the cost of producing rice will be lowered markedly—thus allowing increase in acreage.

The search for varieties or strains of rice which would allow the profitable use of binders is quite timely in view of the extensive preparation being made by the Bureau of Agriculture and some commercial houses in Manila to test the practica-

bility of harvesting rice with machines. Together with high breaking strength, a variety or strain to be harvested economically with a machine, must not shatter easily. We have found that awned or bearded varieties do not shatter easily. The acreage of awned rices, however, is not as large as that of the awnless. Besides, many farmers discriminate against the awned rice because the awn makes hand-or foot-threshing quite difficult. It is a plant breeding problem, therefore, to determine the possibility of isolating from awned varieties, awnless strains of rice which retain the non-shattering quality of the grains. The Plant Breeding Division has started an experiment on this problem. It has been found that the varieties Kinandang Silang, Nagdami and Putyucanon contain both awned and awnless individuals. A test of the awnless plants is under way (48).

As is generally known, a variety of plant possessing a combination of two or more desirable characters may be produced through hybridization. In the case of rice, it becomes at once a question whether or not a variety may be produced which combines beardlessness and non-shattering quality. As far as is known, shattering quality, like beardedness is, in the last analysis, a quantitative or rather a morphological character, for it depends to a great extent on the nature of the attachment of the caryopsis in the head. This attachment consists in a depression or hole at the base of the caryopsis and a small projection of the stem which fits in the hole. The caryopses that do not shatter easily are found to possess deeper holes and longer stem projection. It does not seem impossible, therefore, that shattering quality is a unit character and is represented by a Mendelian factor in the chromosome.

Should it be possible to combine beardlessness and shattering quality by crossing the proper varieties, it would be a practical question to determine how the hybrid would behave in the second and later filial generations. While it is known in the case of wheat and oats that beardlessness is dominant over beardedness (and that the ratios in the second filial generation are 1 beardless: 2 intermediates: 1 bearded, and 3 beardless: 1 bearded, respectively), in rice, as far as the writer is aware, this is not known. With the object of getting a satisfactory answer to this question, preliminary work has been done in rice hybridization. In this experiment, varieties Cruz and Dapalit, two varieties which appear to differ only in the presence of awn, are used. A few important preliminary results have already been obtained. It has been found, for example, that rice grains will develop even if the upper half of the hulls are cut before pollination or even if the hulls are opened at this time and subsequently closed. In the first case, the grain develops half naked. In the second case, it develops either with closed hulls or with hulls partly opened at the top. After determining that rice flowers will stand emasculation which process necessitates the above treatments, crosses were made between the two varieties. So far only a few hybrid seeds have been obtained. These may not succeed in germination as they are without hulls and are shriveled, more or less. The hybridization work in rice will be pushed as vigorously as time will permit (50).

It is to be remarked that in all the above work, the pedigree selection method is being followed; this is the most scientific, and, in the long run, it is considered to be the quickest method of obtaining improvement. A phase of this method of selection is the absence of re-selection in the second and subsequent generations. It is generally recognized that in the offspring of a homozygous self-fertilizing

plant, selection is of no effect. If re-selection is practised at all, as is the case when elites are re-selected every year, it is merely to obtain seed material of known purity for each multiplication culture. This is necessary in work in which, on account of limited labor or laboratory seed space, there is possibility of the pedigree material being contaminated with seed of unknown pedigree. In rice line selection with some Philippine varieties, there is some indication that re-selection may be necessary for another reason—on account of the probability that there exists natural cross fertilization as is the case with some varieties outside the Philippines. What, otherwise, is considered a pure line may, by cross fertilization, be naturally contaminated with other strains or even varieties. In such a case, re-selection will be necessary. Jacobson[2] and Gutierrez ([37]) have reported suspected cases of natural hybrids. The Division of Plant Breeding in this College has begun the investigation of this important problem ([17]). The presence of cross fertilization in rice need not entirely be disadvantageous in breeding; it might be utilized in extensive rice hybridization, as in corn, for the production of first generation hybrids.

A paper on rice that is useful both for experimental and instructional purposes, is the set of laboratory directions, prepared by Rundles, for rice judging and study ([42]). The author of the directions claims it is the first score card ever prepared for rice. It must be remarked, however, that as an attempt to correlate external characters with yielding powers, score cards have usually been a failure. The value of a score card lies mainly in the fact that it aids the student in his ability to judge the crop.

RICE IN ANIMAL HUSBANDRY

Professor Gonzalez of the Department of Animal Husbandry thinks that since rice grain is in large demand for human consumption, it should not be considered as a staple feed for animals. Experiments by Cruz ([52a]) showed that rice, on the whole, was not as good a feed as corn for laying hens, when fed alone When rice was fed in combination with other feeds, as corn and mungo, the results were better than if any one of them was fed alone. Whenever available, and when the price is not prohibitive, it is recommended that, for the sake of variety, rice be used in combination with other grains fed to fowls. Rice is regarded as superior to corn for hard-worked horses. It appears to give more mettle to the animal; while corn produces a soft fat, and allows the animal to sweat freely after exertion. Bautista, ([52b]) experimenting with hogs, found that rice bran was about 25 per cent better than corn when used as supplement feed to pigs on pasture. When used alone in a dry lot, rice bran kept growing pigs in good shape longer than did corn alone.

DISEASES AND PESTS AND THEIR CONTROL

Of the rice pests, the rice bug (*Leptocoriza acuta*) has received most study. As early as 1911, Zamora ([53]) published some observations on its morphology and habits. This year (1919) Mr. Leopoldo Uichanco completed a study of its life history and of its mode of attacking the rice plant ([54]). So far, there is no known method, both economical and applicable on a large scale, for the eradication or control of this pest. Zamora found that kerosene emulsion kills the bugs; but this method is both expensive and difficult to employ. He found also that rotten ani-

[2] Jacobson, H. O., Xenia in rice? Philippine Agricultural Review 7: 361. 1914.

mal matter placed in canes with a bit of wax drives the bugs away; but this method merely shifts the burden of control to neighboring growers. From what Uichanco found regarding the mode and time of attack of the bug on the grain it may be possible to obtain, by selection, rice strains that are naturally resistant to the attack of *Leptocariza acuta.*

Nearly every one who has grown rice at the College has found that birds do considerable damage to the rice heads during the fruiting and harvesting stage. The only method of control is the common one of keeping a laborer in the field to drive away the birds. In experiments carried out on a small scale, it is, of course, possible to prevent injury by bagging the panicles with cheese cloth.

With regard to fungous and bacterial diseases of rice, it may be stated that considerable progress toward control measures has been made at the College by Professor Reinking ([55]). And Mr. Ocfemia ([57]), under the direction of Professor Reinking, of the Department of Plant Pathology, has in progress a study of the rice fungi with special reference to those that cause diseases of rice. Some of the more important objects in this work are: the enumeration of all fungi associated with the rice plant, whether parasitic or saprophytic, including bacteria; the determination of the relation of each organism to the host, and of the damage done by each; the study of morphological and physiological characters of each organism in natural and artificial culture, together with methods of hibernation and infection; and the study of methods by which the organisms may be prevented from infecting plants, and by which their damage may be controlled. Besides a large number of fungi that have been sent by Professor Reinking to Dr. P. A. Saccardo in Italy for identification, of which many are supposed to be new, the following are positively known to be associated with rice at the College ([56]).

Achlya. Water mold.
Bacterial leaf stripe.
Calonectria perpusilla Sacc. On dead glumes.
Cercospora. Leaf spot.
Clasterosporium punctiforme Sacc. On dead glumes.
Coniosporium oryzinum Sacc. On decaying parts.
Entyloma oryzae Syd. On dead leaves.
Haplographium chlorocephalum (Fres.) Grove. On dead glumes.
Helminthosporium. Seedling blight.
Leptosphaeria (*Leptosphaerella*) *oryzina* Sacc. On dead glumes.
Melanomma glumarum Miyake. On dead glumes.
Myrothecium oryzae Sacc. On dead glumes.
Oospora oryzetorum Sacc. On dying glumes.
Ophiobolus oryzinus Sacc. On decaying culms.
Phyllosticta glumarum Sacc. Glume spot.
Phyllosticta miurai K. Miyake. Leaf spot.
Piricularia oryzae Cav. Blast.
Pyrenochaeta oryzae Shirai. On dead sheaths.
Rhizoctonia. Stem rot.
Sclerotium. Stem rot.
Septoria miyake Sacc. On dead glumes.
Sordaria oryzeti Sacc. On rotting culms.
Spegazzinia ornata Sacc. On rotting parts.
Straight or sterile head.
Tip burn.
Ustilaginoidea virens (Cke.) Tak. False smut or lump smut.
Yellowing.

Many of these fungi are very injurious, and work on them, especially on *Helminthosporium, Sclerotium,* and *Rhizoctonia,* is in active progress in the Department of Plant Pathology.

APPENDIX I

LIST OF RICE INVESTIGATIONS, COMPLETED OR IN PROGRESS AT THE COLLEGE OF AGRICULTURE

I. INTRODUCTION OF FOREIGN VARIETIES

Introduction and acclimatization of foreign varieties by the Agronomy Department.

II. STUDY OF VARIETIES

COMPLETED

(1) Octubre, Francisco. Structural characteristics of rice varieties.
(2) Manio, Melecio M. A study of physical characters of Nueva Ecija rice varieties.
(3) Torres, Juan P. Physical characters and local cultivation of Batangas rice varieties.
(4) Dario, Leoncio F. Physical characters of some rice varieties.
(5) Crisostomo, Marcelo S. Cultural notes on upland rice in the Philippines. Philippine Agriculturist and Forester **3**: 111-116. 1914.

IN PROGRESS

(6) Jamias, Julio. Physical characters of some upland rice varieties.
(7) Lontoc, Gregorio. Study of heredity of some important characters of rice.
(8) Morada, Julian. Comparative tests of some upland rice varieties.
(9) Agronomy I Students under Mr. Toribio Vibar. Comparative tests of 60 upland and 60 lowland rice varieties.

III. EXPERIMENTS ON CULTURAL AND OTHER FACTORS

COMPLETED

(10) Roxas, Manuel. The effect of some stimulants upon rice. Philippine Agriculturist and Forester **1**: 89-97. 1911.
(11) Zamora, José. Fertilizers and the growth of rice. Philippine Agriculturist and Forester **1**: 152-154. 1911.
(12) Villegas, Valente E. Some experiments on the growth of rice in water cultures. Philippine Agriculturist and Forester **2**: 86-90. 1912.
(13) Balangue, Cornelio R. Fertilization of rice. Philippine Agriculturist and Forester **5**: 144-158. 1916.
(14) Peralta, Fernando de. A study of the relation of climatic conditions to the vegetative growth and seed production of rice. Philippine Agriculturist **7**: 159-179. 1919.
(15) Esguerra, José P. Mixed planting of corn and rice.
(16) Caseñas, Gregorio G. Comparative production between transplanting and broadcasting lowland rice, including spacing and hilling.
(17) Goco, Arsenio A. Performance and selections of best local up land rices under fertilization. Philippine Agriculturist and Forester **6**: 155-167. 1918.
(18) Trelease, S. F. The growth of rice as related to proportions of fertilizer salts added to soil cultures. Philippine Jour. Sci. **15**. (In press.)
(19) McLean, F. T. et al. Water relation of rice.
(20) Espino, R. B. Some aspects of the salt requirements of young rice plants. (Dissertation in Johns Hopkins University.) Philippine Jour. Sci. **15**. (In press.)

IN PROGRESS

(21) Collado, Isidoro R. Relative value of large and small and heavy and light seed of rice.
(22) Africa, Angel. Comparative study of the different methods of harvesting rice.
(23) Agronomy I Students under Mr. Vibar. Distance of planting rice.
(24) Agronomy I Students under Mr. Vibar. Rate of seeding rice.

(25) AGRONOMY I STUDENTS UNDER MR. VIBAR. Age to transplant rice.
(26) AGRONOMY I STUDENTS UNDER MR. VIBAR. Possibilities of drilling and broadcasting rice.
(27) AGRONOMY I STUDENTS UNDER MR. VIBAR. Monthly planting of rice.
(28) AGRONOMY I STUDENTS UNDER MR. VIBAR. A study of cultural methods employed on farms outside the College.
(29) RICAFRENTE, QUIRICO. Methods of irrigation of rice and yield.
(30) QUISUMBING, EDUARDO. Structure of the root of rice seedlings.
(31) JURADO, MARIANO. Effects of different concentrations and proportions of potassium sulphate, primary calcium phosphate, and ammonium sulphate upon the growth and yield of rice in soil cultures.
(32) PAULINO, PEDRO. Growth of rice in soil cultures containing potassium sulphate, primary calcium phosphate, and ammonium sulphate; and the effects of replacing ammonium sulphate with sodium nitrate, calcium nitrate, and ammonium nitrate.

IV. FARM MANAGEMENT

COMPLETED

(33) AURELIO, CATALINO G. The cost of production of rice by Philippine methods. Philippine Agriculturist and Forester **4**: 29-42. 1915.
(34) ISIDRO, RUFINO. Comparative culture of upland rice and lowland rice.
(35) PAZ, ALFONSO DE LA. Cropping of upland rice by bullock labor.

IN PROGRESS

(36) ASUNCION, RODOLFO. Cost of land preparation in the vicinity of Los Baños.

V. RICE BREEDING

COMPLETED

(37) GUTIERREZ, MARIANO E. Selection of some standard Ilocano and Tagalog lowland rices. Philippine Agriculturist and Forester **6**: 135-154. 1918.
(38) ROMERO, LEON M. Elite culture and multiplication of some standard Ilocano and Tagalog rices. Philippine Agriculturist and Forester **7**: 149-153. 1918.
(39) CABANOS, JUAN B. Culture and multiplication of some standard Ilocano and Tagalog rices
(40) HABALUYAS, RAMON. Multiplication of selected upland rice.
(41) HARDER, TOMAS. Selection of standard Iloilo rices.
(42) RUNDLES, JOHN C. Rice judging and study. Philippine Agriculturist and Forester **3**: 181-190. 1914.

IN PROGRESS

(43) MENDIOLA, N. B. Initial selections of mother plants and test-row-plantings involving 94. varieties of rice, including both lowland and upland.
(44) LABRADOR, ANSELMO. Selection for breaking strength of straw in rice.
(45) YAP, SEVERO G. Selection for early maturing strains of rice, both of upland and lowland.
(46) BERNARDO, FRANCISCO. Selection in rice.
(47) MENDIOLA, N. B. A study of natural cross pollination in rice.
(48) MENDIOLA, N. B. The possibility of isolating awnless rice strains from awned or partly awned varieties.
(49) MENDIOLA, N. B. Comparative tests with rice seeds from the largest and smallest culms of individual plants.
(50) MENDIOLA, N. B. Studies on rice hybridization.
(51) MENDIOLA, N. B. Studies on seed dormancy in rice.

VI. RICE IN ANIMAL HUSBANDRY

(52a) CRUZ, F. F. Experiments on the effect of certain Philippine feeds on growth and production of eggs and meat by poultry. Philippine Agriculturist **7**: 44-54. 1918.
(52b) BAUTISTA, P. Experiments on hog feeding with and without pasture. Philippine Agriculturist **7**: 72-83. 1918.

VII. DISEASES AND PESTS AND THEIR CONTROL

COMPLETED

(53) Zamora, José. *Leptocariza acuta.* Philippine Agriculturist and Forester 1: 8-9. 1911.

(54) Uichanco, Leopoldo. *Leptocariza acuta* and its relation to rice.

(55) Reinking, O. A. Philippine economic-plant diseases. Phil. Jour. Sci. Sec. A, 13: 157-274. *Pl. 1-22, fig. 1-43.* 1918.

(56) Reinking, O. A. Host index of diseases of economic plants in the Philippines. Philippine Agriculturist 8: 38-54. 1919.

IN PROGRESS

(57) Ocfemia, Gerardo. A study of rice fungi with special reference to those which cause disease.

APPENDIX II

LIST OF RICE PROJECTS FOR IMMEDIATE FUTURE

I. INTRODUCTION OF FOREIGN VARIETIES

The work begun will be continued.

II. STUDY OF VARIETIES

(1) Introduction and tests, under Los Baños conditions, of lowland and upland varieties of rice from different parts of the Islands.

(2) The advantages of awnless rice over the bearded rice.

(3) Chemical study of standard varieties of rice.

III. STUDY OF CULTURAL AND OTHER FACTORS

REPORTED BY PROFESSOR ELAYDA

(4) Longevity of rice seed.

(5) The difference between the Ilocano and Tagalog methods of preparing rice seed-bed.

(6) Difference between rice seedlings grown in seed-bed and grown in "dapog".

(7) Comparison between fertilized and unfertilized seed-beds as to the subsequent growth of seedlings in permanent field.

(8) Seasonal plantings of upland and lowland rice varieties.

(9) Drilled rice *versus* broadcasted rice.

(10) Transplanted compared with broadcasted paddy rice.

(11) Simultaneous planting of rice and corn in the same field.

(12) Investigation as to the best depth to plant rice.

(13) Fertilizers for paddy rice.

(14) Fertilizers for upland rice.

(15) Comparative yield of upland rice and lowland rice as a response to a separate application of carabao manure and horse manure.

(16) Residual effect of artificial and natural manures on rice.

(17) Effect on the fertility of the land of simultaneous planting of rice and peanuts (or other legumes) in the same field.

(18) Effect of rice intercrop in a coconut plantation.

(19) Results of lowland or upland rice culture alternated with mungo, as practised by the Filipino farmer.

(20) Effect of rice and legume intercrops in a coconut plantation.

(21) A study of lowland rice rotated with farm beans.

(22) A study of crop-rotation in paddy fields.

(23) A study of crop-rotation with upland rice.

(24) How to prepare and seed ground for upland rice in order to dispense with weeding during the development of the crop.

(21) The use of grain binder for rice.

(26) Investigation of rice yields in the various provinces: Bulacan, Nueva Ecija, Pangasinan, Tarlac, Laguna, Cotabato, etc.

IV. RICE FARM MANAGEMENT

REPORTED BY PROFESSOR ELAYDA

(27) Expenses of upland culture by the use of animals compared with the use of a tractor.

(28) Investigation of labor income of several farmers who produce rice exclusively.

(29) The relation of management and crop production to rice farming.

(30) Conditions determining the success or failure of a rice producer.

REPORTED BY PROFESSOR HESTER

(31) It is planned to make a survey of yield, cost, income, and distribution of income over one hundred typical lowland, and one hundred typical upland rice cultures in Laguna or in Rizal or in both.

V. RICE BREEDING, INCLUDING SELECTION

REPORTED BY PROFESSOR ELAYDA

(32) Comparative results of selected and unselected standard varieties of lowland rice on a large scale.

(33) Same for upland rice.

(34) Measurement of results of rice cultures by farmers who practice seed selection.

(35) Rice selection for protein content.

(36) Rice selection for phosphorus content.

REPORTED BY THE PLANT BREEDING DIVISION

(37) Further studies on selection and hybridization.

A REVIEW OF THE COCONUT INVESTIGATIONS AT THE COLLEGE OF AGRICULTURE[1]

By Rafael B. Espino
Of the Division of Crop Physiology, Department of Agronomy

The discussion in this paper is mainly based on the results obtained from observations or experiments on the coconut carried out at the College of Agriculture, Los Baños, P. I., together with statements from different departments of the College in regard to the present and future projects on this plant or its products. Up to the present, or during the period of ten years since the establishment of this College, there have been nine important original published investigations on the subject; five of these were from the Department of Chemistry, and four deal with the chemistry of the nut and of its oil. With the exception of those reported by Dr. Copeland in his book, *The Coco-nut* (4), only one piece of investigation deals with observations on the behavior of the plants in the field. The large number of published articles based on chemical studies as compared with the number on field observations is due, in part, to the fact that most of the investigators were thesis students whose time for research is so limited that they are compelled to select a piece of investigation that will give results within a short period of time. Another explanation that might be offered is the fact that the coconut tree requires from four to ten years before fruits are produced; this period depends, of course, upon the variety and the environmental conditions present during the growing stage of the tree. And to these may be added the fact that the present College Farm is rather unsuitable for the growing of good coconut trees. This is because the soil, on a large part of the Farm, is rather shallow, and because this region is frequently visited by prolonged drought—a condition that is known to the coconut producers to be detrimental to the tree's growth.

In spite of these limitations considerable work on the coconut has been completed or is now under way. Nine complete studies await publication, and ten are in progress; and there are about sixteen well-planned projects that can be taken up as soon as men and facilities will warrant. The results of the studies mentioned will be presented below under the headings:

Study of varieties.
Coconut and environment.
Chemistry of the coconut.
Cultural experiments.
Diseases and pests.

The investigations in progress and those that are to be taken up in the near future will appear in the discussion under appropriate headings, and a list of these projects as well as of other literature on the subject will appear in the "Literature Cited."

STUDY OF VARIETIES

There are several known varieties of coconut in the Philippines, and there are several others that are not found here, but that are grown in other countries.

[1] Experiment Station contribution, No. 25.

According to Copeland, the varieties of coconuts that are found in the Philippines may be grouped into about four distinct types, namely, (1) the San Ramon Nut; (2) the Laguna Nut; (3) the Coco-niño or the baby coconut; and (4) the Pugai, a very dwarf nut.

Each of these representative types of nuts in the Philippines has its own characteristics and is especially good for certain economic purposes or uses. (1) The San Ramon Nut, for instance, is a very large and productive coconut. Copeland reported that the average production year after year on the San Ramon Hacienda and the neighboring plantations, is one picul of copra from every 200 nuts, or that 3,270 nuts are required to produce one ton of copra. The 200 nuts for one picul of copra is also reported in the Census of 1903 as the average number of nuts of the San Ramon type required to produce this amount of copra. The coconut that is a good source of copra is also a good source of coconut oil. (2) The Laguna Nut is the type represented by the most commonly grown coconuts in the Islands. The average number of these nuts required to make one ton of copra is 5,600. This type, Copeland states, represents the typical coconut of the whole world. (3) The Coco-niño, or baby-coconut, is found only in certain parts of the Philippines. This coconut is reported to be growing side by side with the San Ramon nut in Zamboanga. It requires 7,000 or more nuts of this type to produce one ton of copra. Unlike the first two types mentioned, this nut is an early producer. It produces fruits at the age of four years, while the San Ramon and the Laguna varieties produce nuts at the age of six, eight or even as late as ten years. (4) The Pugai is a dwarf nut. It is found, Copeland reports, in Camarines; and apparently the same variety is found also in Pangasinan and Zambales. A nut from this variety is about seven centimeters in diameter, surrounded by a husk not more than two centimeters in thickness. This variety has been observed to produce fruit at the age of three years.

Besides these varieties there are two or three other varieties which are intermediate in size between the two last named varieties.

In regard to the products that may be derived from the fruits of these different types, or varieties of coconut, those of the two types first named are very suitable for the manufacture of copra or of oil. The other two varieties do not grow very tall and are capable of producing a considerable number of fruiting clusters and are early fruit-producing varieties; these are, therefore, suited for the production of toddy.

In this College attempts have been made to introduce coconuts of two or three varieties in addition to the Laguna type that is most commonly grown in this locality. In 1913 a few nuts from Leyte, and probably from Mindanao also, were germinated, and the seedlings were transplanted along the College fence near the Church. The varieties imported were the Mangipod and the San Ramon nuts. Apparently the seedlings served only as targets for the insects *Oryctes* and the *Rhynchophorus;* all of these seedlings have long been dead.

The only variety of coconut we have now growing on the College Farm is the Laguna variety. There are about 74 mature trees. Ten years ago, when the College first purchased these trees, there were twice as many as there are now. At that time they were from to 8 or 12 years old. Many of the trees that died were the victims, primarily, of the attack of insects, *Oryctes* and *Rhynchophorus*,

but the shallow rocky soil and the frequent visits of prolonged droughts contributed to bring about their death. The remaining trees have few leaves, are badly injured by insects, and are unproductive.

Besides the trees just mentioned there are 384 trees growing at the foot of Mount Makiling. These trees were planted in 1914 and 1915 by Mr. P. U. Bocomo from selected seeds obtained from the older trees growing on the College Farm and from Pangasinan. The seedlings are set in the plantation (now called the Bocomo Coconut Plantation) 10 meters apart, and the ground immediately surrounding each tree has received applications of fertilizer. This Bocomo plantation, with the exception of about 100 trees, was burned over during the summer of 1917 and again in 1919, when the heavy growth of *Imperata*, *Andropogon*, *Saccharum spontaneum*, and of other weeds growing between rows of coconut trees was accidentally set on fire. The effect of the fire on the coconut trees, although severe, killed less than ten trees, and the trees now are beginning to recover from the injury.

From the foregoing paragraphs it is quite apparent that this College, which should have as many varieties of this plant as it can possibly obtain, has only one variety—the Laguna. And it is also apparent that the College Farm is not an ideal place for the cultivation of coconut, because of the shallow and rocky soil and the frequent visits of prolonged drought. Because of the great economic importance of the products obtained from the coconut trees, the College should purchase land that is as nearly as possible ideal for the growing of coconut; on this land all varieties in the Islands and, if possible, those from other countries should be planted side by side for careful and constant observation by members of this College and others interested in the coconut.

If we had these materials at our disposal we could determine which varieties are early in producing fruits and which are late The productiveness of the varieties might also be compared. One variety, for example, may prove to be most suitable for the production of copra or of oil, while other varieties are probably, as suggested by Copeland, best for the production of toddy or of other products. And, if we had these varieties side by side, it would be quite possible to carry out hybridization experiments that might bring very valuable results for the coconut planters. By this means it might be possible to obtain a hybrid-coconut that would combine the large fruits and productiveness of the San Ramon type with the dwarf and prolific habits of one of the dwarf varieties.

THE COCONUT AND THE ENVIRONMENT

One of the most important factors in securing information in regard to coconut physiologically, agronomically, and commercially, is the class of Agronomy II of this College. In order to secure these data the members of this class are expected to carry out experiments in the laboratory and in the field, and they are further expected to make careful observations and secure data on the coconut industry as practised in some towns of the provinces of Laguna and of Tayabas. For these experiments and investigations, directions for the work were prepared by Dr. Copeland, then dean of the College; these were published in the *Philippine Agriculturist and Forester* ([2]). These directions include experiments on the germination of nuts; transplanting of seedlings; maintenance of clean grove; the study of the root system, including the counting of the number of roots and observations

on the depth to which the roots penetrate the soil, rate of growth, and absorption of water by the roots; the rate of growth, of the leaves, spathes, and of the nuts; rate of transpiration; collection of toddy; and complete directions to be followed in making trips to coconut producing localities.

The information gathered by the members of Agronomy II Class during a period of five years under the supervision of Dr. Copeland served to amplify and substantiate the latter's work on the physiology of the coconut performed by him in San Ramon, Mindanao. As a result of all this work, Dr. Copeland in 1914 published his book, *The Coco-nut* ([4]), which has been praised highly by authorities on coconut, and which is now being used as a text-book in the Agronomy II class of this College.

Before going into the contents of this book about the coconut plant in relation to its environment, it might be said here that the aim, its author says, "is to give the knowledge and advice which will qualify a person for the practice of coconut raising." The author states that there are two general methods which might be followed in coconut raising. "One is to give rules which have been found good in practice; the other is to give understanding on which such rules must rest." This book, as well as the methods followed in teaching the course of Agronomy II, observes the latter method; for the coconut planter who has been given understanding in the fundamentals of the method will be likely to succeed under any conditions he meets.

In his valuable book, *The Coco-nut*, it should be mentioned, that Copeland states that, besides the stomata, the coconut has another structure that has to do with transpiration. This structure which he calls the "hinge" is composed of colorless thin-walled cells. These cells readily become turgid or flaccid. The behavior of the "hinge" on the leaf of the coconut was also studied by Dr. Trelease and his Plant Nutrition III class ([20]); this study is a continuation of studies on the water-relations begun by Copeland. It is known that during the middle of the day the halves of the pinnae of coconut droop and approach each other, while early in the morning and at night the two halves are held as far apart as possible. Dr. Trelease and his students carried out experiments to determine whether changes in the angle between the halves of the leaf may be used as indices of alterations of the incipient drying of the leaf as a whole. These investigators also made a study of the relation between such leaf-movement and changes in the environmental conditions controlling the water-relations of the plants — evaporating power of the air, sunlight, temperature, soil moisture, etc. It appears probable, says Dr. Trelease, that in the coconut the leaf-movements are associated with changes in moisture content of thin-walled, turgescent cells forming a "hinge" near the midrib, and that these changes may be used as indices of changes in water content of the leaf as a whole. These studies, Dr. Trelease believes, indicate that these leaf-movements might be useful in connection with the practice of irrigation, and might be of more value in suggesting an economical basis for irrigation than mere appearance of the plant or of the soil.

In connection with the rate of the loss of water from the coconut tree, Dr. Copeland states that transpiration is influenced not only by the movement of the "hinge" in the leaf of this plant but also by light, warmth, dryness of the air, and wind. It is also hindered by darkness, cold, and moistness and stillness of the air. The most important of these, Dr. Copeland states, is light. He says,

"a light haze across the sun—too light to be called a cloud—will immediately reduce the transpiration by one-third or one-half. A cloud heavy enough to conceal the sun will promptly cut it down to about one-quarter of what it is in direct sunshine. All shade has, of course, the same effect, and it makes no difference whether it comes from a cloud, or a mountain, or some shade tree, or another coconut planted too near. Every leaf or part of a leaf which is in the shade has its transpiration cut down to a quarter of what it might be, and, therefore, gets only a quarter of the food it might get dissolved in the water."

Dr. McLean ([15]) also studied the rate of transpiration from the coconut leaf and found that the water loss from the under surface is much greater than from the upper surface. He says that the ratio between the two was not uniform.

In co-operation with the members of Plant Nutrition III, Dr. Trelease ([21]) studied the hourly fluctuations of the transpiring power of the coconut leaf, throughout the day and night, by means of standardized cobalt chloride paper, using the method suggested by Livingston and Shreve. These studies have shown that under usual environmental conditions the ability of the leaves to give off moisture by evaporation increased in the morning to a maximum value a few hours after sunrise; it then decreased slowly until about sunset, when it decreased rapidly to a low night value. The hourly march of transpiring power of the coconut leaf thus resembled that of other plants studied in a similar manner. Dr. Trelease states that the transpiring power of the plant is controlled by the leaf area, the number, distribution, and openness of the stomata, the amount of water in the leaf, etc.; and that the actual amount of water transpired in a certain period of time depends not only upon the transpiring power of the plant but also upon the external conditions surrounding the plant. The latter, Dr. Trelease says, include temperature, moisture content and movement of the air, intensity of the sunshine, amount of water in the soil, etc.

In addition to the study of transpiration from the leaf of coconut, Dr. McLean ([16]) also studied the coconut photosynthesis. From the results of tests made every two hours for seven days, on the leaves of one tree, he found that photosynthesis during the dry season was most rapid in the early morning and late afternoon. The rate, he says, was very rapid just after sunrise, fell until 1 to 2 p. m., rose again between 2 and 4 p.m. and fell towards sunset. He further says, that the youngest leaf of the coconut, which had not yet expanded, showed slow photosynthesis, the three leaves next youngest, showed the most rapid photosynthesis,and the oldest leaves absorbed carbon dioxide very slowly.

Further discussion dealing with the climate and soil as these influence the growth and development of the coconut plant, is given in Chapter II of Copeland's *The Coco-nut* ([4]).

CHEMISTRY OF THE COCONUT

The College of Agriculture, (particularly the Agronomy-II Division) is fortunate in that the Department of Chemistry is very much interested in the chemistry of the coconut and its products.

In 1914, a studyof the ripening of the coconut was taken up by Mr. B. M. Gonzalez ([5]). In this study, he analyzed different parts of the nuts in different stages of development, and from the results obtained he arrived at the conclusion that changes taking place during the ripening of the coconut might be divided into

three periods: (1) During the first period no meat had formed, the husk was green, the shell was soft, and the nut as a whole was at its greatest diameter. In this stage an accumulation of invert sugar and of amino acid was observed in the milk. (2) The appearance of the sucrose in the milk in a large quantity marked what Gonzalez regards as the second period of growth. During all this time the amount of water in the nut decreased, though the total weight of the nut itself increased. (3) The third period of the growth and development of the fruit of the coconut, this writer says, was characterized by an increase in oil content in the endosperm. The specific gravity of the milk fell. The shell of the nut and the husk became dry.

Another study, similar to that of Gonzalez, was undertaken by Vista (9), who made numerous analyses of the nuts of known stages of development. The analyses made by Gonzalez were based merely on the size, color, and thickness of the meat—characteristics which he used in determining the relative ages of the nuts. Vista made a series of analyses and found that with one exception his results were in agreement with those of Gonzalez. And, in addition, Vista found: (1) The meat began to form when the nut was about six months old. (2) When the meat was about one millimeter in thickness only invert sugar was found in it. (3) The nitrogen content of the meat increased as the nuts matured. (4) At the germination stage of the nuts the percentages of sucrose and of invert sugar in the milk increased rapidly. A similar increase of these sugars was observed in the meat. There are indications, Vista says, that the nitrogen constituents of the meat are first used by the germinating plant before the endosperm is used, and (5)with this particular variety of nut, a period of from 370 to 410 days was required before the nut became fully ripe (counting from the time the spathe opened).

Another study of the chemistry of the coconut was made in 1914 by Gonzalez (6). In this study he used the "makapuno" seeds instead of the ordinary type. He analyzed, also, normal nuts and the results obtained were used to compare with those he obtained from the "makapuno" nut. In this comparison he found that the solid portion of the "makapuno" nut was slightly richer in protein than "the common nut," but was considerably poorer in oil. The soft portion of the "makapuno" contained more protein and oil than did the milk of the normal nut." Although this investigator did not attempt to give any physiological explanation for the appearance of "makapuno" nut, he suggested that a more thorough chemical study should be carried out in connection with its carbohydrates and protein contents. He, also, raised the question as to why the nut of this type always failed to germinate.

In regard to the amount of oil obtained, Villyar (11) found that it varied according to the size and degree of ripeness of the nuts used. The total amount of oil in a nut he found in his study ranged from 40.1 per cent to 64.6 per cent of the dry weight of the meat, or had an average of 54.4 per cent.

The Department of Chemistry, under the direct supervision of Professor Ashton, is making the following studies:

A study of the various acids present in coconut oil as obtained under different conditions (25).

A study of essential oils present in coconut oil (24).

A study of influence of sunlight on coconut oil (26).

Also, Professor Ashton is contemplating taking up in the near future the following investigations:

Influence of the method of preparation on chemical and physical properties of coconut oil (33).

Quantity and quality of oils from nuts from different regions as correlated with soil and climatic conditions (34).

Quantity and quality of oils from nuts of different varieties (35).

To this list may be added the chemical changes taking place in the coconut meat which is kept tightly sealed in the shell of the nut. This study may be carried on in connection with the possibility of keeping the meat of the coconut in good condition in the shell, or of producing copra in the shell—probably by preventing germination of the seeds and checking the entrance of organisms into the shell.

The copra-meal has also received some attention from our chemists in the College. So far, there has been but a very limited amount of work on this subject. Mr. F. O. Santos (19) made a preliminary study on the nitrogen partition in that portion of copra-meal insoluble in hot water, using Van Slyke's method of determining the protein. He also tried to determine the proteins soluble in different solvents, both qualitatively and quantitatively. Santos found that the copra meal was rich in the amino-acids necessary for maintenance and growth; also that the alkali-soluble proteins were the most abundant in copra meal. Of the actual amount of protein nitrogen, Santos found only 47.55 per cent, which is much less than what was obtained by Osborne and Campbell with lupine seeds.

The Chemistry Department is investigating, under the direct supervision of Dr. Roxas, the value of copra meal as feed. This is a biological study of the deficiencies of the copra meal as food for guinea pigs. It is the thesis of A. Derecho (27). The purpose of this work, says Dr. Roxas, is to find out the quality and relative quantity of proteins, mineral salts, and the growth-promoting and the anti-polyneuritic accessories in copra meal. Dr. Roxas states that the work will have a practical bearing on the scientific use of this product as animal feed.

Dr. Roxas is also contemplating taking up the study of the nature of the proteins in the copra meal by chemical analysis (36). This piece of work, he says will be a continuation of Santos's thesis.

Dr. Roxas further plans to make a study of the carbohydrates of the coconut (37). He says that this is more scientific than practical in nature. Likewise, he expects to make a study of the preparation of creosote oil, acetone, and acetic acid from the coconut shells (38).

The lipase in the coconut was studied in 1914 by Roxas (7), who found that lipase was present in the germinating coconut both as an enzyme and as a zymogen. He found also that this substance occurred mainly in the outer part of the foot, or cotyledon. A smaller amount of this substance was also detected in the milk and in the portions near the inner surface of the endosperm. Roxas found that the action of the lipase could be checked by the application of four-tenths per cent of either potassium cyanide or sodium arsenate; that five per cent thymol solution had no noticeable effect on the action of the enzyme; and that boiling weakened but did not destroy the enzyme. He found, also, that the

lipase worked best when magnesium oxide was added to the medium containing this enzyme, or in other words, it worked best when the medium was practically neutral.

CULTURAL EXPERIMENTS

In this report, the term Farm Management is used in a rather broad sense, and embraces all work on the coconut from the germination of the seeds up to the disposal of the product.

In 1917, Bacomo ([10]) made the first extensive study of coconut seedlings at this College, in fact the first in the Philippines. He used about two thousand seeds, mostly of Laguna type, though some were from Pangasinan. Before undertaking this work, this investigator had in mind that the coconut industry in the Philippines might be improved (1) by seed selection from the better strains; (2) by proper spacing of the plants; (3) by harvesting the nuts at the proper time; (4) by proper preparation of the products for the market; and (5) by judicious application of fertilizers, natural or artificial. For his experiments, Bacomo selected nuts from productive trees of the Laguna type, germinated them, and set out the seedlings—placing them in holes ten meters apart and following the quincunx arrangement. The results of Bacomo's observation on germination of the nuts in the seed bed led him to conclude that, while it is not advisable for the nuts to be planted in the seed bed before they are ripe, it is likewise undesirable that they should be planted very long after ripeness, because there is danger that the plumule will become fixed in the direction of growth inside the husk, which will result in a deformed seedling. In this connection, in 1911, Roxas ([1]) reported that the coconut seedlings are transplanted usually when they are from six to twenty-four months old. This writer suggests that the seedlings should be transplanted early in order to get a good start for the seedlings. To this suggestion may be added that by Bacomo ([10]), who states that transplanting of the coconut seedling is possible without injury at the beginning of the rainy season and should be practiced only at this time. Dr. Copeland makes the following statements:

> Germination itself requires from three to six months. The most rapid development can be expected if the seedlings are transplanted into the field before the plumule exceeds 15 centimeters in height. If it is to be expected that this practice will be followed, then the seed beds need not be cultivated to a depth of more than 20 centimeters, unless deeper cultivation will result in a better supply of ground water, and, therefore, in an economy of sprinkling; and the nuts ought not to be buried for more than a third of their own thickness. In such a case also the nuts may be placed in a contact, side by side. If, on the other hand, it is anticipated that the nuts must remain in the seed bed for a year or more, then the soil in the seed bed ought to be worked fine to a depth of at least 30 centimeters. The nuts may well be buried to about their entire thickness, and there should be left between the neighboring nuts a space, the width of which must depend upon the size which the seedlings will reach before they are transplanted.

As to the spacing of coconut trees in the permanent field, Roxas ([1]) expresses the idea that this is to be determined by the fertility of the soil; he suggests that in rich soil for coconut, the trees should be set farther apart than in soils where the coconut is not doing well, basing his idea on the fact that, in what is called rich soil, thriftier trees are produced and these occupy more space in the soil and in the air. He does not, however, recommend any definite distance between the trees.

Regarding soils for the coconut, the best for this plant, says Copeland, as well as for most other crops, are those of alluvial plains. According to

Copeland's observation, these "soils are rich in food [materials], easily worked, and even without cultivation usually permit a very perfect development of the root system." Copeland also states that sandy seashores are suitable places for coconut cultivation because "they have back of them higher country, and the rainfall which falls on this higher country sinks into the soil and then moves in the soil toward the sea, carrying with it food [materials] which it dissolves as it moves. It time of drought, the amount of such water naturally decreases, but the seashore itself, being the place where such water necessarily comes close to the surface of the ground, is the last place to suffer from the scarcity of it."

Having the kinds of soil best suited for the cultivation of the coconut already ascertained, the next points to determine are the difficulties usually met with in securing and preparing the plantation. Without discussing this topic in detail it might be said these difficulties may be in the form of (1) cost of the land; (2) thickness, and the kinds of the vegetation growing in the prospective plantation; (3) contour of the land; (4) transportation facilities; (5) cost of labor; and (6) scarcity of labor.

Assuming that the field is now ready as far as clearing is concerned, the next thing to do is to line the field and to dig the holes. Besides the quincunx arrangement followed by Bacomo ([10]) in setting his coconut seedlings, there is another possible and practicable arrangement, by square. Both Copeland ([4]) and Roxas ([1]) recommend the use of the quincunx method. Copeland states that by this method, at the distance of 10 meters between trees, each hectare of ground will support 115.47 trees, instead of 100 trees with the same area of ground and the same distance between trees by the square method. Roxas states that the quincunx has the advantage in that every tree is equidistant from its neighbors and has about 11 per cent more trees on a given area than the square. As already mentioned Roxas does not suggest any definite distance between the trees. In this connection Copeland reviews in his book the different distances used in the coconut producing regions of the world, with a statement or two in regard to the apparent conditions of the trees resulting from the way the trees are set in the field. He says that the distances between trees in practice in the world, range from 4 meters to 13 meters, and suggests that the distance to be adopted should be determined by the climatic and soil conditions of the place. He agrees with Roxas, in that, if the conditions are unfavorable, the trees may be planted somewhat closer together. Copeland, however, believes that the distance should never be less than eight meters. Well-planned field experiments on planting the coconut trees should be started as soon as opportunity offers, either by this College in a suitable coconut locality, or by a rich coconut planter who has land in a place well-suited to the cultivation of the coconut.

No one in this college, except Dr. Copeland, has discussed the size of the hole in which the coconut seedling is to be planted; he says, in part, "in actual practice, it is probable that most coconuts when transplanted are set into holes just large enough to receive them. Such extreme economy of labor certainly does not pay. There are probably no economic conditions in any place such that it would not be worth while to open a hole at least 35 centimeters wide and deep." This recommendation in regard to the size of the holes is not only reasonable but should be put into actual field tests, using different kinds of soil

supposed to be good for the coconut. Seedlings of coconut of uniform development and age should be planted in holes of different sizes. In a few years, this experiment should show differences in the growth and development of the trees—most particularly in the distribution of the roots in the soil and the depth to which the roots penetrate the soil (a condition which has a direct relation with the practice of cultivation of the plantation and the practice of catch-cropping or inter-cropping). If it is possible, at all, to induce the coconut plants to produce roots that will grow and remain deeply buried in the ground, instead of making the superficial growth usually observed, this will be accomplished probably by selecting the right kind of soil, by proper cultivation, or by planting the seedlings deep into the ground and cultivating frequently.

It should be said here, in addition to the preceding suggestions, that as soon as opportunity permits field tests should be made on a number of other problems. (1) The effect of intercrops should be determined. (2) The effect of cultivation on the growth and development of the plants should be determined. This should be done by starting two plantations identical in every respect—in soil, climate, and in the age and variety of the nuts used. One of these fields should be kept under thorough cultivation; the other should either be neglected, or the weeds should be cut but not eradicated. (3) The proper time for transplanting the seedlings should be ascertained. We ought not merely to accept the recommendation already stated in one of the preceding paragraphs, but should make amplified field trials. For this purpose, seeds from selected trees of known productiveness for a number of years should be germinated, and the nuts or the seedlings from this lot should be transplanted into the field at different stages of development. (4) Professor Elayda suggests making investigations of the cost of producing copra, oil, and other products of the coconut. He says that this will include farm management investigation of the crop by provinces or by other suitable regions. This will comprise, he also says, the tenancy system in connection with coconuts; the effect of large coconut plantations on the welfare of the people in general; and the effect of fostering coconut growing under the present system of our social conditions.

Professor Elayda made a further suggestion, which in the opinion of the writer is excellent—namely, that investigations be made on the climate and soil conditions affecting unfavorably the growth and development of the coconut tree. In places, such as Los Baños, where coconut growing is said to be unprofitable, it is worth while, Professor Elayda thinks, to find by actual trials whether the coconut industry can be made to pay by using the very best methods of cultivation—the application of irrigation water, the use of proper time and frequency of cultivation, the application of fertilizers, etc.

Turning now to the application of fertilizer on the coconut plantation, Bacomo ([10]) states that the object of his experiment, mentioned in one of the foregoing paragraphs, was "to study the effect of different combinations of fertilizers on the growth of seedlings after transplanting". In order to attain this object, Bacomo applied fertilizers of different kinds to the soil immediately near the coconut seedlings. He used the external appearance of the plants and the rate of growth of the leaves as indicators of the effectiveness of the fertilizers. The results obtained showed that the most rapid growth of the seedlings during the first three months was observed in those plants that received the application of

131.6 grams of ammonium sulphate. Bacomo found that a large application of nitrate of soda (500 grams) caused poor growth of the seedlings. At the time when Bacomo presented this study for his thesis, he said that he had not been able to find whether the application of commercial fertilizers is practicable or not. Although this experiment of Bacomo's gave satisfactory results, yet these results are only of value for the particular soil, climate and variety and age of the coconut seedlings used in the experiment. And the fertilizer found by him to be the best in promoting the growth and development of the seedlings would probably not have been found to be the best if other fertilizers or fertilizer-combinations had been applied to these seedlings. Although salt-requirement experiments are relatively easy to carry out with small field crops, such as rice and wheat, similar experiments with coconuts are not very feasible. The reason for this is obvious. The root-system of the coconut seedling or tree is so large that it requires a considerable space; and the plant requires a number of years before it reaches its mature stage. It is, therefore, impracticable, if not impossible, to carry out solution culture experiments under controlled conditions to determine the salt-requirements of this plant (including the proper proportions, and the most suitable concentration). And the problem is rendered more complex when it is realized that best proportions and concentration for the young seedlings of wheat, of buckwheat, or of soy bean, are found not to be best for the mature plants, this condition might be true also in the case of the coconut.

These unfavorable conditions should not, however, prevent this College or any other institution, corporation, or rich planter, from carrying out field experiments on the fertilizer requirements of the coconut. The results of experiments of this nature, especially with a permanent crop like the coconut—which constantly and continuously draws out food-materials from the soil, until the latter is more or less depleted of its constituents good as food nutrient for the coconut—would surely be valuable to the coconut planter.

Use commercial fertilizers. These commercial fertilizers should be selected according to their respective merits as fertilizers—as sources of N, of P, or of K. We are assuming that other essential elements for plants are either supplied by these fertilizers or are found in the soil. Having these conditions in mind, the next step is to combine three or four of these fertilizers—rich in N, P and K respectively—following the method of preparation suggested in Schreiner and Skinner.[2] Two or three concentrations or amounts of the combined fertilizers should be used, applying one fertilizer proportion to at least three trees. If possible, the more trees tested with one fertilizer combination the better, because this procedure corrects, to some extent, the effects of individual variations of the plants. This kind of study, of course, requires a considerable number of coconut plants. Among the criteria to be used in judging the value of the fertilizer mixtures should be: the apparent vigor of the plants; the number and the size of the nuts produced by each tree; the earliness in the production of fruits; and the oil content of the fruits.

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[2] Schreiner, O., and Skinner, J. J., The triangle system for fertilizer experiments. Jour. Amer. Soc. Agron. **10**: 225-246. 1918.

Very little information has been gathered at this college in regard to the economics of the coconut industry. Mr. M. B. Raymundo ([18]), in a report to the Dean on the possibility of growing coconuts on farms around Los Baños, mentions the difficulties which he encountered in securing data, stating "it is rather impossible to obtain concrete data regarding the production of coconuts in this region, for nearly all of the planters do not keep any accounts of their own plantation". Raymundo states that he gathered the data he presented in his report, "from ten reliable farmers, each owning a plantation of from 100 trees to 800 trees". He found that the maximum yield per tree annually was about ₱0.60, while the minimum yield ran as low as ₱0.20; the average yield was ₱0.45 per tree per year. Upon computation Raymundo found that the yield per hectare, according to the distance of planting practiced in this locality, was about ₱70.00 a year. "This, of course," Raymundo says, "was a gross profit, so the cost of the maintenance of the plantation was not considered". According to the prospectus prepared by him, "it will take seventeen years for a planter to pay the total investment and get an income of ₱50.00 per hectare per year. The life of a tree, due to the climatic conditions and character of the soil, is approximately thirty years". In conclusion, Raymundo states "it is not advisable, by any means, to grow coconuts commercially around Los Baños".

Although coconut growing in this region is evidently unprofitable as now practiced, it should be of great value to agriculture to determine whether by proper modifications coconut cultivation cannot be made profitable. The following modifications are suggested; some of these have already been mentioned.

1. The selection of the variety or varieties of coconuts which, through field tests, have proved to be best suited for planting on farms around Los Baños.
2. The selection of the seeds of coconut based on the individual, continuous high productiveness of the mother tree.
3. Systematic or schematic investigation of the fertilizer requirements of the coconuts in this locality.
4. The selection of deep soil rich in humus, instead of the rocky soil.
5. Proper spacing in planting, which, according to Copeland, should not be less than eight meters between trees.
6. Digging of rather large holes in which to set the seedlings.
7. The use of irrigation water during the summer season or during prolonged drought.
8. The establishment of an extensive coconut plantation; this will undoubtedly reduce greatly the evaporation of moisture from the ground and at the same time decrease the injury caused by the "oang".
9. Co-operation of the planters should be obtained in the extermination of "oang" at all stages of its life-history and in the destruction of breeding places for these insects and other organisms that cause disease.
10. The planters should be cautioned not to use cacao, papaya, or rubber trees as intercrops for coconut; because, as was reported by Professor Reinking, these plants are susceptible to *Phytophthora faberi*, which has been found to be the cause of the bud-rot of coconut in the Philippines.
11. Proper cultivation and the use of cover crops might probably help in improving the condition of the coconut.

Other pieces of investigation on the production of the coconut have been carried out by Mr. Vista ([23]). This investigator kept careful record of the number of nuts harvested from each tree at each time a harvest was made. In this study he had under observation about 500 trees growing on his own plantation at Rizal, Laguna. This study was begun in 1916 and was continued until October,

1919. The amount of data collected is, in Vista's opinion, sufficient to give very valuable information regarding the rate at which individual coconut trees produce nuts. Unfortunately, the data have not yet been studied, and no generalization can be included in this report.

Related to the investigation made by Vista is the study that has been begun by the Agronomy II class this year. This study deals with the size of the coconut trunk in relation to the vigor of the plant as shown by the condition of the crown and by productiveness and size of nuts. It will be extended to include some coconut sections in the province of Laguna, when the class makes the required trip this year.

Although the size of the trunk may have no direct relation to the development of the crown which it supports, and likewise the size of the trunk may have no direct bearing on the size and number of nuts produced, yet there are indications that the larger the crown of the tree the more productive it is and the larger the nuts produced—a condition which is in direct agreement with physiological principles.

Another piece of work that the Agronomy II is planning to undertake this year is an investigation on the size and shape of the nut (with or without the husk) and its relation to the thickness, oil content, etc., of the meat-content of the nut. The main object of this investigation is to find out which nut is best adapted for the manufacture of copra. Thus, with this information, it will be possible not only to gather nuts for seeds from highly productive trees but also to select nuts of a certain definite shape and size.

Villyar ([11]) described the different methods of extracting oil, after having made a careful study of the efficiency of the native oil press method. He concluded that the native husker, "tapasan," was very efficient, and that the rattan bags, "andulan," did not need any substitute. To increase the efficiency in the extraction of oil, Villyar suggests that the teeth of the scraper, "kabyawan," should be made very fine; that the rectangular furnace fitted with one chimney and two caldrons should be employed instead of the conical type; that the boiling caldrons should have higher sides; and that the double-screw type of press, "hapitan," should be used instead of the single-row type.

In regard to the amount of oil obtained, Villyar found, as is given elsewhere in this paper, that it varied according to the size and ripeness of the nuts used. Villyar also found that there was a considerable loss of oil in using the native method of extraction, as is shown in the following table:

Sources of Loss.	Range.		
	Minimum.	Maximum.	Average.
	Per Cent.	*Per Cent.*	*Per Cent.*
Scraping the meat	1.6	10.3	6.0
Boiling the meat	0.4	3.5	2.0
Grinding the meat	6.2	15.1	10.7
With cake	2.9	13.9	8.4
With latic	4.8	8.4	6.6

To these losses of oil, Villyar added the loss of oil by leakage through the trough and by piling the coconut meat on the ground; and he calculated roughly that the grand total of the losses amounted to about 34.5 per cent.

This investigator compared the efficiency of the native method of extracting oil with that of the modern and said that the former extracted only about from 41.4 to 75.2 per cent, or an average of 65.5 per cent of oil from the meat, while the latter can extract as much as 93 per cent.

In concluding his work, Villyar suggests the following possible improvements of the coconut oil industry in the regions or towns where he made his study:

1. Co-operation among coconut growers should be urged in order to guard against loss of money brought about by poor cultural methods and to guard against improper handling of the coconut products.
2. Employment of modern method of preparing copra and extracting oil.
3. That nuts for the manufacture of copra and of oil should be well matured to obtain a maximum yield.
4. Passing of laws that might improve the transportation facilities for the coconut products.

In 1914, Dr. Copeland (3) gave some advice to coconut planters regarding special measures to be taken during war conditions. He advised that the first thing to be done by the planter was to abandon the bad practice of cutting nuts from the trees. Instead, he advocated allowing the nuts to fall on the ground of themselves, for in this way the nuts would be sure to be well matured—good copra cannot be made from unripe nuts. Copra made from fully ripe nuts, said Dr. Copeland, can be kept for a number of years with little deterioration.

A piece of investigation the results of which may prove to be of value when coconut planters are confronted with a poor market for their copra, is to be started in January, 1920. This study is on the possibility of keeping the meat of coconut in good condition in the shell—or the possibility of producing copra in the shell. A brief outline of this work was presented to Dean Baker, and it was explained to him that the writer got his idea about this work from examining more than one hundred nuts which he found in one corner of the Seed House; some of these nuts had been stored in the Seed House for two or three years. The nuts were shaken, and those that had no water inside were cut open. It was found that in the nuts which had not germinated the meat was in perfect condition, as copra, inside the shell, while in the nuts that had started to germinate the meat was destroyed, spoiled or eaten by some organism. This condition suggested, therefore, that if the nuts could be prevented from germinating, the "destructive organisms," which in this case happen to be fungi, would probably not get unto the inside of the nut. A series of experiments will soon be started on this question, in which about 4,000 nuts will be employed and the test will be made under different possible conditions and should extend over a period of several years. To give further ideas on the nature of the experiment, it may be stated here that materials, such as paraffine, lime, wax, "sahing" (latex of *Canarium*), latex of Antipolo and others, will be used to plug the eye of the nut, so as to prevent germination and to keep out organisms.

A thesis, the main object of which is to find out whether it will pay or not to grow coconuts for toddy, rather than for copra, is in the process of preparation by M. Villaraza. Villaraza could not furnish the writer with a complete list of the results obtained from his investigation for he has not yet made all the computations. He was, however, kind enough to furnish the following information: (1) more toddy was collected during the rainy season than in the dry season;

(2) the collection of toddy was greater on the day after a rain; (3) it took about one week to bend the peduncle of the inflorescence to such a position that the collection of the toddy was possible; (4) the practice in Majayjay is to cut two or three inflorescences for the collection of the toddy.

The last item under this heading, is a statement or two about the experiments which the Agronomy II class is carrying out on the extermination, by means of the so-called "cover-crops," of weeds, such as *Andropogon, Imperata, Saccharum spontaneum*, and other species, that are found growing in a young coconut plantation. For this purpose a portion of the Bacomo coconut plantation is being used and the following plants have been planted between the rows of coconut:

1. *Manihot utilissima*, cuttings.
2. *Cajanus cajan*, seeds.
3. *Phaseolus lunatus*, seeds.
4. *Phaseolus calcaratus*, seeds.
5. *Estezolobium lyonii*, seeds.
6. *Leucaena glauca*, seeds.
7. Dried leaves, stem of *Andropogon*, etc.
8. *Psophocarpus tetragonolobus*, seeds.
9. *Crotalaria* (2 or 3 species), seeds.

This experiment has just been started, so that it is impossible at present to make any generalizations. It should be said, however, that it is a continuation or amplification of the work of Neric on the extermination of cogon.

DISEASES AND PESTS

The longest chapter in Dr. Copeland's book, *The Coco-nut* (4), is devoted exclusively to diseases and pests of the coconut. This discussion covers 77 pages of the 212 pages contained in the whole book. A review of this subject as presented by Dr. Copeland will not be included in this report. Instead of this, all other available work on this topic carried out at this College will be presented.

Foremost of all the fungus or bacterial diseases of the coconut, is the disease commonly known as bud rot. This disease, as its name implies, has its seat in the bud at the top of the coconut plant. Quoting other authorities, Professor Reinking says that the bud rot of coconut is the source of severe losses of this plant in nearly all parts of the tropics where it is cultivated. There have been several investigations carried out on this disease, and various organisms have been considered responsible for it. Professor Reinking says that the first authentic and reliable observations on the bud rot of coconut in the Philippines were made in 1908 by Dr. Copeland. The disease was then reported to be prevalent in the coconut sections of the provinces of Laguna and Tayabas, especially around the towns of Lilio and Nagcarlang in Laguna. It was also reported, by the Bureau of Agriculture of the Philippines, to be prevalent in Pangasinan and Zambales provinces, and quite lately the disease has been reported by Mr. G. Merino of the Bureau of Agriculture, to be also found in Zamboanga.

Besides Professor Reinking of this College, there have been also other investigators interested in the subject. Without enumerating them all it may be said that Johnston, who worked on coconut bud rot in the West Indies, arrived at the conclusion that the disease is caused by a bacterium similar to *Bacillus coli* (Esch.) Mig. And another investigator, Butler, presented evidence to prove that bud rot of palms in India is caused by *Pythium palmivorum* Butl.

Recently, Professor Reinking ([13]), after conducting experiments in the laboratory and inoculations on the coconut seedlings and mature trees, arrived at the conclusion that the organism responsible for the bud rot of coconut in the Philippines is the fungus *Phytophthora faberi* Maubl. Professor Reinking believes that this fungus is the primary agent in the production of the infection and that bacteria are to be regarded only as the secondary agents. The following summary may be made of Professor Reinking's work:

1. Enormous losses, amounting to thousands of pesos each year, have been produced by coconut bud rot. As shown by the Bureau of Agriculture reports, the disease has been most prevalent in Laguna, Tayabas, Pangasinan, and Zamboanga provinces. It is most abundant in very humid sections and in thickly planted groves, both of which conditions are found on the slopes of Mount Banahao. Field studies have shown that the spread might be extremely rapid during favorable weather.

2. An organism similar to *Bacillus coli* (Escherich) Mig., and other saprophytic bacteria have been found to be associated with the disease. Under certain conditions, such as a host weakened by severe injury, the former organism and *Bacillus coli* (Escherich) Mig. isolated from man or horse, might in inoculation experiments produce the disease.

3. A summary of the entire bacteriological work done by the present writer, including, approximately three hundred inoculations, indicates that, while the bacteria were always present and were a factor in destroying the weakened tissues, they could not account for the initiation of the disease or its prevalence and rapid spread.

4. *Phytophthora faberi* Maubl. isolated from cacao produced a typical bud rot of coconut seedlings and of mature coconut trees.

5. A fungus isolated from a typical field case of coconut bud rot was found to be identical with the *Phytophthora faberi* Maubl. isolated from cacao.

6. *Phytophthora faberi* Maubl. isolated from the field case of coconut bud rot produced in all inoculated seedlings a typical infection.

7. *Phytophthora faberi* Maubl. isolated from the field case of coconut bud rot produced disease in coconut seedlings, cacao fruit, *Hevea* rubber seedlings, and papaya fruit. The same species of fungus isolated from cacao fruit produced disease in coconut seedlings and mature trees, cacao fruit and stem, *Hevea* rubber seedlings and mature trees, and papaya fruit.

8. A morphologic and taxonomic study of the organism isolated from coconut has proved that it is *Phytophthora faberi* Maubl., as described by Rosenbaum.[3]

9. From these researches it can be stated with certainty that *Phytophthora faberi* Maubl. causes coconut bud rot; bacteria apparently always secondary, but are concerned with destroying the weakened tissues.

10. By proving that the fungus causing coconut bud rot was identical with the organism which produced black rot of cacao pods, canker of cacao, fruit rot and canker of *Hevea* rubber, and rot of papaya fruit, it becomes evident that an entirely new series of controls will have to be devised. *Phytophthora faberi* Maubl. has been found to grow readily, under favorable conditions, as a saprophyte, also, on dead portions of coconut, cacao, and papaya.

In connection with the results obtained by him from experiments on the bud rot of coconut of the Philippines, Professor Reinking ([13]) is the authority for the following statements and recommendations:

1. Trees when once severely infected never recover. The mode of growth of the palms and the nature of the disease make it impossible to cure the trees already badly affected.

2. Systematic inspection, condemning and burning of all diseased coconut trees, as carried on by the Bureau of Agriculture, should be continued.

3. All parts of diseased trees must be burned; otherwise the organism will live as a saprophyte on dead matter, and then spread to healthy trees.

4. Clean cultivation ought to be practised in all groves.

5. Under no circumstances should coconuts be interplanted with cacao or papayas.

[3] Rosenbaum, J. Studies of the genus Phytophthora. Jour. Agric. Res. 8:233-276. 1917.

6. If coconuts are planted near diseased *Hevea* rubber, precautions should be taken to prevent the spread of the disease.

7. Trees in new groves should be planted 10 meters apart each way. This spacing is one of the most satisfactory means of control against bud rot, and at the same time tends to give the highest production of nuts.

Under the Department of Plant Pathology of this College, the following investigations on coconut diseases are in progress: (1) A study of coconut root rot. (2) A study of the rot of the trunk of coconut. Professor Reinking (14) reports a total number of 29 fungi associated with coconut; these include both parasitic and saprophytic organisms.

Regarding the insect pests of the coconut, no report has been made on this subject at this College except the discussion presented by Copeland in his book, *The Coco-nut* (4). The members of Agronomy II, of this year, however, when dissecting coconut trees found two dying coconut trees in which the crowns were badly destroyed and decayed on account of the insects "*oang*". The class collected *Oryctes* and *Rhyncophorus* at different stages of their life-history with the exception of the eggs. It is recommended that all dead coconut trees standing in the grove be cut down and disposed of, so as to get rid of possible breeding places for the "oang".

Before closing this report, it should be said that valuable as Copeland's book, *The Coco-nut* (4), has been, it will in the near future require a revision in order to include the more recent findings on the coconut plant and its products.

In a similar manner, the directions for the laboratory and field work of the Agronomy II class of this College, which were prepared by Dr. Copeland five or six years ago, should be modified. A revised outline is in course of preparation by the writer.

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III. IN PROGRESS.

UNDER THE CHEMISTRY DEPARTMENT

(24) A study of essential oils present in coconut oil.
(25) A study of the various acids present in coconut oil as obtained under different conditions.
(26) A study of influence of sunlight on coconut oil.
(27) The nutrition properties of copra meal. (By A. Derecho.)

UNDER PLANT PATHOLOGY DEPARTMENT

(28) A further study of the Philippine bud rot of the coconut.
(29) A study of coconut root-rot.
(30) A rot of the trunk of coconut.

UNDER THE AGRONOMY II DIVISION

(31) Extermination of weeds in a young coconut plantation.
(32) The trunk and its relation to the development of the crown and the production of the nuts.

IV. FUTURE PROJECTS

UNDER THE CHEMISTRY DEPARTMENT

(33) Influence of method of preparation of chemical and physical properties of coconut oil.
(34) Quantity and quality of oils from nuts from different regions as correlated with soil and climatic conditions.
(35) Quantity and quality of oils from nuts of different varieties.
(36) A study of the nature of the proteins of copra meal by chemical analysis.
(37) A study of the carbohydrates of the coconut.
(38) The preparation of creosote oil, acetone, and acetic acid from coconut shells.

UNDER THE DEPARTMENT OF AGRONOMY

(39) Size and shape of the nut as indicators of its meat content.
(40) A study on the effect and length of effect of the fertilizers applied in Bocomo plantation, on the coconut plants.
(41) A study on the possibility of keeping the meat of coconut in good condition in the shell; or the possibilities of producing and keeping copra in good condition in the coconut shells.
(42) Pedigree culture of different varieties of coconuts.
(43) Several experiments on the effect of fertilizers upon coconut plants.
(44) The effect of distance between the trees on the growth and development of the plants and upon the production of nuts.
(45) The effect of intercrops on the young coconut trees, and the determination of the best plant for intercrop.
(46) The effect of cultivation on the coconut plants.
(47) The effect of irrigation water on the growth and development of the coconut.
(48) Proper size of the holes and the proper time for transplanting.
(49) Coconut industry as practised in Tayabas compared with that in Laguna.
(50) The use of fertilizers, irrigation water and intensive cultivation as means of improving the coconut condition in and around Los Baños.
(51) Best means for extermination of "oang".

SUGAR CANE INVESTIGATIONS AT THE COLLEGE OF AGRICULTURE[1]

By Manuel L. Roxas
Of the Department of Chemistry

Because cane sugar is one of the important products of the Philippines, the College of Agriculture has felt, since its foundation, the necessity of solving some of the pressing problems in connection with the raising of this crop here. The College, however, has never been in a position to undertake any thorough and systematic work along this line, and what little has been accomplished was done spasmodically under adverse conditions.

The work on sugar at the College has been on the following problems:

1. Cane "seed" and its treatment.
2. Methods of planting cane.
3. Variety tests.
4. Effects of fertilizers on sugar cane.
5. Diseases of sugar cane.
6. Chemical composition as affected by variety and age.
7. Methods of manufacture.

CANE SEED AND ITS TREATMENT

Sugar cane is usually propagated by cuttings, which are called *seed* by sugar planters. As a general proposition, selection of seed cane is recommended as one way of improving the industry. This precaution, however, is generally neglected by the Filipino farmer, perhaps because of lack of data to demonstrate to him the extent of its importance. Adriano (1) worked on the problem and showed the extent of the gain from seed selection. The following table taken from his paper clearly indicates that using cuttings from the best and healthiest plants will increase the yield of cane per hectare.

	No. of seed planted.	Av. length of usable cane.	No. of canes produced.	Production of canes per stool.
		cm.		
Selected seed	12	119	86	3 to 18
Revillegas's cane (unselected)	12	109	27	1 to 5
S. Cruz's cane (unselected)	12	115	29	1 to 7

The part of the cane to plant is another problem taken up by Adriano. The general practice among farmers is to plant tops, since these are of no use for making sugar; and, as they contain most of the ash constituents of the plant, it is supposed they produce stronger canes. This belief has been supported by Adriano's results. There are some localities, however, where seeds are badly needed for increasing the area planted and where the tops produced are not

[1] Experiment Station contribution, No. 26.

sufficient for the planter's needs. To meet such a condition, Adriano's results showed that butts, if soaked in water for 48 hours, were next to the tops the best part of the cane to plant. The practice on some estates is to grow small lots of canes, which after three or four months are cut and divided into parts for further planting. The process is repeated until enough seeds are produced for the entire field. The use of butts, provided these are soaked in running water for 48 hours, will double the seeds that can be obtained from a given field of cane and may obviate the necessity of planting cane exclusively for seed. Then the practice of specially planting for seed will need to be resorted to during the first year only in starting a plantation.

METHODS OF PLANTING

The method of planting, the space between cane seeds, whether the seed should be planted flat or slanting, and the depth of planting, are questions of very great importance in the cultivation of sugar cane. The common practice in the locality of this College is to plant the seeds slanting, at a distance of about 60×30 centimeters and at a depth of about 15 centimeters. The spacing used in the Calamba Sugar Estate is 1.5 meters×0—that is, seeds are laid end to end in furrows 1.5 meters apart.

The method of planting cane seeds has been the subject of a number of investigations at the College. Tempongko (2) shows that a spacing of 120×50 centimeters gave the best results. Adriano compared the native method of spacing with the use of 1.5×0.5 meters and obtained the following comparative figures:

Yield of native method per hectare	18.6 tons
Yield of 1.5 × .5method per hectare	32.9 tons

("Both cultures when young were badly injured by locusts.")

Adriano also found that seeds planted flat in the ground at a depth of 30 centimeters did better through the dry weather than when planted 15 centimeters deep in the same manner.

More extensive experiments on spacing were conducted by Mirasol (3) in 1916. His experiments involved the study of 15 plots, and the spacing varied from the native method to one using 1.75×0.75 meters, with seeds laid flat and slanting. Each plot contained 450 square meters. The Sinanduyong variety of cane was used. The yields of cane in tons per hectare of the different plots varied from 53 to 82 tons, and the sucrose content from 10.66 to 14.65. Mirasol concludes from his experiments that the percentage of success in germination was higher while the susceptibility of the cane to disease was lower in the widely than in the narrowly spaced, and that suckering was favored by wide spacing. The highest yield of sugar was obtained from the plot using a distance of 150×50 centimeters with seeds laid flat.

The best method of cultivation and the right spacing vary with the nature of soil and climate, and are purely local problems, so that the results obtained at the College are not strictly applicable elsewhere. As a general proposition, however, the ground for cane as for every other crop should be kept in good tilth and the seed spacing should allow of proper cultivation during the first seven or eight months. It may safely be stated that the distance between the rows of seed should not be less than 1.20 meters.

VARIETY TESTS

The hectare yields of the varieties grown in the Philippines do not compare favorably with those in the leading sugar countries. And it looks as though the introduction of new varieties, or the creation of local ones that will better our present canes, is a field of endeavor that may yield profitable results. This College has studied the local varieties for yield (in tons of cane per hectare) and for sucrose and fiber content. Adriano (1) studied the following native varieties, descriptions of which are given in his paper:

Sinanduyong, Zambales, White Bamboo, Negros or Purple, and College numbers 70, 299, 896 and 897. "Of these eight varieties only one is grown throughout the vicinity where this experiment was conducted. It is true that this one [the White Bamboo] proves to be best in production among the seven other varieties." The average yield of the White Bamboo cane in the College is about 57 tons of cane, or about 6.0 tons of sugar, per hectare.

With the idea of determining whether the introduction of foreign varieties would better the canes in this vicinity, a number of cuttings were obtained from the Bureau of Agriculture and planted in the College for propagation. When sufficient seeds were available, work on a comparative study of these varieties fair-sized plots was started by Mr. Deogracias Villadolid (4). A summary of his work (still unpublished) is given below.

The seed used in these experiments were cuttings from plants grown from the best stocks imported by the Bureau of Agriculture from Hawaii and Louisiana. They were H309, H27, H69, H20, H220, H16, H227, Louisiana striped (L. S.), Yellow Caledonia (Y. C.), and Lahaina (L.). Two plantings of these varieties were studied. The first planting was in December, 1916, in a plot 72×40 meters. The seed were placed slanting, 40×150 centimeters apart. There were from 5 to 7 rows for each variety. The soil used was shallow and rather poor, and had produced just previously two crops of peanuts.

The second planting was in December, 1917, and a plot 67.5×50 meters was devoted to each variety. The plots were on a richer but heavier soil, which had produced, a short time before, a crop of peanuts. The results are summarized in the following table, which also includes, for comparison, results obtained elsewhere in the Philippines.

Comparison of results of the present experiments with results obtained with samples from other sources

Variety of cane.	Tons (short) of cane per Hectare.			Percentage of sucrose in cane.			Percentage of fiber in cane.			Purity of the juice.			Resistance to diseases and pests.		
	Present experiment.	Calamba Sugar Estate.	La Carlota Experiment Station.	Present experiment.	Calamba Sugar Estate.	La Carlota Experiment Station.	Present Experiment.	Calamba Sugar Estate.	La Carlota Experiment Station.	Present experiment.	Calamba Sugar Estate.	La Carlota Experiment Station.	Present experiment.	Calamba Sugar Estate.	La Carlota Experiment Station.
Hawaii 309.....	62.25	—	122.0	9.033	—	15.65	12.5-13.0	—	11.0–13.5	71.74	—	85.83	Severely attacked	—	—
Hawaii 220.....	102.08	—	—	10.200	—	—	12.5–13.5	—	—	82.22	—	—	Severely attacked	—	—
Hawaii 27.....	50.33	—	80.0	10.290	—	14.47	13.0–13.5	—	11.0–13.0	80.67	—	83.81	Slightly attacked	—	—
Yellow Caledonia..	126.75	82.4	174.0	11.640	9.11	13.12	12.5–13.0	—	11.0–14.0	80.16	78.30	79.17	Very hardy	—	—
Louisiana striped..	79.54	67.52	115.0	13.450	10.3	16.58	11.5–12.0	—	10.5–13.0	87.23	84.8	87.06	Very hardy	—	—
Hawaii 227.....	74.94	—	96.0	8.91	—	13.94	12.0–13.0	—	11.5–13.0	76.40	—	80.74	Very slightly attacked	—	—
Hawaii 69.....	86.51	—	84.0	8.10	—	12.53	12.5–13.5	—	10.5–13.0	73.66	—	79.86	Very slightly attacked	—	—
Hawaii 16.....	12.11	—	83.0	7.62	—	13.24	12.5–13.0	—	10.0–13.0	66.35	—	84.67	Hardy	—	—
Lahaina.....	24.89	—	81.0	15.89	—	17.18	11.0–12.0	—	10.5–12.5	89.96	—	90.57	Slightly attacked	—	—
Hawaii 20.....	30.49	—	91.0	12.29	—	14.53	13.0–13.5	—	11.0–13.5	84.53	—	86.00	Slightly	—	—

Mr. Fairchild (5), of the Mindoro Sugar Company, is of the opinion that the cane that would be best suited to the conditions in these Islands would be one with an extensive root system, numerous suckers, and a medium height. If all these qualities are accompanied by a high sucrose content, an ideal cane for the Islands will be had. It should be possible to create such a cane here. The best method of creating a new variety of cane, and the one recognized the world over as having produced the best cane varieties in known sugar districts, is the growing and selection of canes from seeds,[2] which may be either hybrids of native or foreign varieties or otherwise. The following is an abstract of an unpublished report by Dr. N. B. Mendiola, in charge of the breeding division of the College, on work in this line.

It is generally believed now that improvement of sugar cane is to be found in the production of new varieties not by the ordinary stool selection but by tests of seeds, especially those which are hybrids. The need of breeding new varieties for the sugar industry was voiced in 1914 by Professor Baker[3] and more recently by Mr. Dumas of the Calamba Sugar Estate and by Mr. Fairchild, who is also one of the foremost men in the sugar business.

As a breeding project in sugar cane work, the Plant Breeding Division of the College began in a preliminary way a year ago experiments in germinating sugar cane seed[2] with a view of carrying on seedling tests afterwards. The season last year was very favorable for the production of the sugar cane flowers, and many *arrows* were collected from the different cane fields in flower in the College. Germination tests of seeds from these arrows failed to produce any seedlings. The varieties tested were the following:

College number.	*Variety name.*
3456	Sinanduyong
5513	Native White
5514	Native Purple
5515	Soft White
5516	Soft Red
5517	Cabilawan
5518	Hard Red
5568	H–16
5569	H–20
5570	H–27
5571	H–69
5572	H–220
5573	H–227
5574	H–309
5575	H–Lahaina
5576	H–Yellow Caledonia
5583	H–Louisiana Striped
1834	Sinanduyong
1836	Los Baños

Seed bearing College number 10879, obtained from an abandoned field in Muntinlupa, Laguna, were included in the test because of a statement sometimes made that seeds from old ratoons are usually fertile. But these Muntinlupa seed failed to germinate.

Small quantities of seed of different sugar cane varieties were obtained from the Bureau of Agriculture through Mr. Marquez and Mr. Victorio. These varieties bear the following names and College numbers:

College number.	*Variety name.*
10881	Chinosis
10882	Mauritius Melagaches

[2] *Seed* is here used in the botanical sense.

[3] Baker, C. F., The breeding and selection of sugar cane. Australian Sugar Journal 6: 78-79. 1914.

10883	Uba
10884	Java—143
10885	Hawaii—20
10886	Demerara
10887	826—P. O. J.
10888	Benguet White
10889	Mexican Striped
10890	Demerara—604 Cuban
10891	Hawaii—109
10892	Malabour
10893	1499—P. O. J.
10894	Tigbao Mestizo
10914	Hawaii—69
10915	Badila
10916	Big Tanna
10917	O—95
10918	Yellow Caledonia
10919	Hawaii—27

Of this latter set, only No. 10882 produced seedlings.

The work of germinating sugar cane seeds is being resumed this season with renewed effort. Nearly all varieties of cane growing in the College have already flowered, and at the present writing some 10,000 seedlings have already been obtained.

It is obvious that much of the success of this kind of work depends on the co-operation of the cane planters themselves. The greater the number of sources of seeds, the greater is the chance of obtaining seedlings of the desired sort. We are inviting all sugar planters in the Philippines to send us ripe seeds of sugar cane, and we promise to test these as fast as they come. We realize that the planters do not usually have time to carry out this kind of an experiment.

EFFECT OF FERTILIZERS ON SUGAR CANE

The first work on fertilizers for sugar cane was done by Tempongko (2) in 1911, who attempted to determine the influence of N-K-P mixture, with and without addition of dried blood, on (*a*) suckering; (*b*) growth of cane in length; (*c*) growth of cane in circumference; (*d*) production of leaves; (*e*) color of foliage and (*f*) yield of stripped cane per hectare. The fertilizer mixture was made with ammonium sulphate, potassium sulphate, and calcium phosphate in the proportion of 2 parts N, 3 parts K, and 5 parts P. The mixture was applied at the rates of 200 and 400 kilograms per hectare. When dried blood was used in addition, it was applied at the rate of 150 kilograms per hectare. Tempongko's results showed that the percentage of harvestable suckers was increased by fertilizer; and that fertilizers brought about a higher rate of growth in length, heavier stalks, and more abundant leaf production. The yield of stripped cane was found to be higher in the fertilized than in the check plots.

The fertilizer problem was again taken up, in 1913, by Asunción (6). For reasons not stated, the fertilizers were applied late—over five months after planting. Then a severe drought followed with no possibility of irrigation. The experiments were, however, carried to completion; but, because of the drought and the late application of fertilizers, the results were vitiated and no definite conclusions were drawn. Some of the results showed that liming was beneficial in this particular soil, since the limed plot produced about twice as much cane per hectare as the unlimed (21.8 tons to 13.5 tons cane).

A more thorough and rational work on the effects of fertilizers on sugar cane was carried out by Mirasol (7) in 1916, using the Los Baños White variety, which

had been previously found by the same investigator to yield without fertilization 5.86 tons of 96° sugar per hectare. Selected seeds were used. They were planted 150×25 centimeters apart, between May 8 and 10, 1916. The percentage of germination was on the average 81. The fertilizers were applied when the plants were about 2½ months old. Thirteen different combinations were used. An 8-6-8 complete fertilizer mixture[4] was employed, applying it at the rate of one metric ton per hectare and at a cost of from 217 to 280 pesos. One plot received, besides a complete mixture, an additional amount (0.32 ton per hectare) of nitrate of soda, two months after the application of the mixture. The following fertilizers were used: lime, dried blood, sulphate of ammonia, nitrate of soda, sulphate of potash, and double superphosphate. The results showed that sulphate of potash alone and the complete fertilizer with nitrate of soda as the source of N, produced the purest juice, while the double superphosphate with either form of nitrogen decreased the ratio of sucrose to total solids of the juice; that the sucrose curve ran parallel with the purity; that sulphate of ammonia with either sulphate of potash or double superphosphate increased the yield of cane per hectare, but that the increase in tonnage was not accompanied by a corresponding increase in the available sugar, and that finally the use of complete fertilizer gave a net gain of about 533 pesos per hectare (or twice the cost of the fertilizer mixture used and its application). In addition to the above conclusions the following points are evident from the study of the tables given.

1. Fertilization increased the height of the canes to a slight extent only, by not more than 13 per cent.

2. The diameter of the cane was increased by fertilization by not more than 18 per cent.

3. Tillering was increased by not more than 12 per cent.

4. The tonnage was increased by not more than 24 per cent.

5. The yield of sugar per hectare was increased from 7.84 to 13.0 (or 67 per cent).

6. The greatest change produced in the case by the use of fertilizers was in the per cent of sucrose, which was increased from 12.86 (average for control plots) to a maximum of 17.78 (or by about 39 per cent).

Soil analyses of the plots used in these fertilizer experiments were not made, but an idea of their composition may be had from analyses of some College soil samples made by Cox with the help of Arguelles, of the Bureau of Science, and published by Cox (8).

Analyses of soil samples from College Farm. Sample A taken from field on right side of road entering the College grounds; sample B taken from field on left side of road entering the College grounds.[a]

MECHANICAL ANALYSIS

Sample A.	Detritus not passing 1 mm. sieve.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.10 mm.	Very fine sand, 0.10 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, less than 0.005 mm.
Surface.....	5.46	3.35	6.44	6.52	9.46	35.80	39.21
Subsoil.....	7.25	2.81	6.41	6.62	9.58	32.68	42.13

[4] This fertilizer mixture contained 8 parts of potash, 6 parts of phosphoric acid, and 8 parts of nitrogen.

MECHANICAL ANALYSIS—(*Continued*)

Sample B.							
Surface.....	8.63	4.63	9.39	10.33	10.99	31.61	33.38
Subsoil.....	8.88	3.58	6.62	6.80	8.62	32.12	40.20

CHEMICAL ANALYSIS

Sample A.	Moisture	Loss in ignition	Nitrogen	Phosphoric anhydride	Lime (MgO)	Magnesia (MgO)	Potash (K_2O)	Soda (Na_2O)	Humus	Soil acidity	Fine earth
Surface.....	11.35	10.90	0.113	0.173	—	0.56	0.328	1.63	1.51	0.0126	94.5
Subsoil.....	11.10	10.86	0.131	0.207	—	1.12	0.304	1.97	1.21	0.0126	92.8
Sample B.											
Surface.....	9.57	10.57	0.126	0.196	—	—	0.321	1.35	1.42	0.0143	91.4
Subsoil.....	10.10	11.22	0.111	0.222	—	1.27	0.361	1.10	1.31	0.0154	91.1

a Numbers give percentages.

DISEASES OF SUGAR CANE

The important diseases of the sugar cane have been studied to some extent by members of the College staff. A résumé of this work is given in Dr. Copeland's article (12), an abstract of which is given below:

The sugar cane is like every other principal crop of the Philippines in never having received a comprehensive study of its diseases and pests. It is further true that no one of the diseases or pests doing very considerable damage has as yet been the subject of careful investigation. Collections of insects and fungi made in past years by the Bureau of Science have included a number of the parasites of sugar cane, and, for a number of years, an effort has been made at the College of Agriculture to secure information as comprehensive as the facilities permitted on this subject. In this effort, taking into account both fungi and insects, Professor Baker has been the leader. The following statement of our present information on the subject is the result of a conference in which Professor Baker, Associate Professor Banks, Assistant Professor Reinking, and Mr. Uichanco contributed information.

Of the fungus enemies of plants which are commonly spoken of as causing diseases, the following are at present known in the Philippines:

Puccinia Kuehnii (Krueg) Butl., the sugar cane rust. This attacks the leaves, and, while far from rare, is not known to do really serious damage here. It must, however, be regarded as of economic importance.

Ustilago Sacchari Rabh, the sugar cane smut. This attacks young canes and is occasionally found in cane fields, in which it is quite destructive. It may be controlled easily by burning all diseased shoots, and taking care in planting to use only healthy tips.

Bakerophoma Sacchari Diedicke. This fungus produces spots on the midrib and at the base of the blade of the leaf. Although first discovered a year or two ago, it is very common in this vicinity and is probably present in all sugar cane sections of the Islands. It lowers the vitality of the plant but does not destroy it.

Cercospora. There are several species of this genus on sugar cane in the Philippines. All produce leaf spots, which are commonly found in Laguna Province and all other sugar producing districts and countries. It lowers the vitality of the cane without killing it.

Phyllachora Sacchari Henn. is another fungus which does not seem at present to be of economic importance, but which, judging by the behavior of its relatives, might easily become so.

Meliola Arundinis Pat. is a fungus parasite of our cane which is unlikely ever to do damage of importance.

Apiospora camtospora Penz. et Sacc. *Coniosporium extremorum* Syd. and *C. vinosum* (Berk. et Curt.) Sacc. are fungi commonly found on dead leaves of cane which may possibly encroach on living tissue, or have some connection with fungi starting on living leaves.

Of rind diseases, there are probably several. *Melanconium sacchari* Cooke, which is the cause of the best known rind disease of canes elsewhere, is rather common here in poorly kept fields. Either close planting or lack of cultivation and consequent low vitality may result in the practical destruction of a crop by this fungus.

Of fungi attacking the roots, *Dyctyophora phalloidea* and a *Marasmius* are found here: both are recognized as enemies in Hawaii, and the latter is widely feared.

With regard to the fungus diseases of Philippine sugar cane in general, it may be stated that they do extensive damage, but that the extent of this is very largely due to the prevalence of exceedingly close planting of the cane and to the very general absence of proper cultivation. The effectiveness of good cultivation in decreasing damage by these diseases is very well illustrated by the relative immunity of fields on the Calamba Sugar Estate, as compared with the many relatively uncultivated fields in the same neighborhood.

Before leaving the plant enemies of cane, it must be noted that we have also a flowering plant, one of the broomrapes, *Arginetia* indica, which is a root parasite on cane and some other grasses and was reported several years ago as doing appreciable destruction in a field near Santa Cruz, Laguna.

Work on the diseases of sugar cane is being continued at the College by the Department of Plant Pathology, under the direction of Prof. O. A. Reinking. The most recent work on the causes, symptoms, and control of diseases may be found in an article by Reinking (13). For a complete list of the diseases of cane in the Philippines the reader is referred to an article by Reinking (14) appearing in the *Philippine Agriculturist.*

CHEMICAL COMPOSITION OF THE VARIETIES OF CANE GROWN AT THE COLLEGE

It is well known that composition of the cane stalk changes with age, season, soil, method of cultivation, and variety. Thus the work done in any single place must needs be of local value. The College has studied the chemical composition of a number of native varieties, and the results have shown their relative merits for the districts around the College. This problem was taken up by Mirasol (9). Three native varieties were studied: the Sinanduyong, the Los Baños White Bamboo, and the Zambalez White. The Sinanduyong contained the highest sucrose content, highest purity, and least fiber content; the Los Baños White cane next; and the Zambales third. The Los Baños White was considered by the author the best for milling purposes. As already stated, this variety is the cane most extensively grown in this locality. The approximate stage at which the three varieties mature was determined for the 1915 season. It was found that the Zambalez White reached the age of purest and maximum sucrose content in 10 months and 8 days, the Los Baños White in 10 months and 29 days, and the Sinanduyong in 11 months. The maturity age of the cane for subsequent years has not been determined.

Mr. Deogracias Villadolid (4) studied the chemical composition of the foreign varieties and found that Louisiana striped and Lahaina were the only varieties which at the period of maximum sucrose content compared well with the native in this respect. The foreign varieties contained from 11 to 13.5 per cent of fiber.

CHEMICAL COMPOSITION AS AFFECTED BY VARIETY AND AGE

Unpublished work has been done by Mr. Valentin Erese (10) on the effect of the age and variety of cane on the standard methods of sucrose determination. Sucrose in cane juice is determined by polarization. But it is known that other optically active substances are present in the juice, and these interfere more or less with this determination. The true sucrose content may be determined by the Clerget inversion method, but this is usually long and is not ordinarily employed in sugar factories as the basis of control of sucrose in juice. The extent of deviation of sucrose in juice by simple polarization, from the true sucrose content by Clerget's method has not been systematically determined under Philippine conditions. Since polarization of the juice is used for computing the available sugar from the cane, and since the latter is used as a basis for determining the part corresponding to the grower, it has been deemed of importance to determine to what extent simple polarization deviates from the true sucrose content of the juice for the different conditions of the cane grown at the College. This was accomplished by comparative proximate analysis of the juice from different varieties of cane, at different ages. Although the work was left incomplete because of Mr. Erese's enlistment in the National Guard, sufficient evidence was obtained to indicate that considerable deviations, worth considering, do occur. The work is being carried on by Delfin Divinagracia.

MANUFACTURE OF CANE SUGAR

Because of lack of facilities the College has had to depend on neighboring centrals for this most important phase of the work in the sugar industry. The Calamba Sugar Estate has been most kind in allowing students from this College to work in their factory. A description of this central was published by Labayen (11).

Of great importance in the Philippine Sugar Industry is the improvement of native methods for small planters. For the small planter, milling cane in a central is no more profitable than in the native mill, since 50 per cent of the available sugar in the crop is paid for milling. The only advantage of a central to the small farmer lies in the fact that he is saved the trouble incident to milling. The cost of machinery at the present time makes it impossible for the small Filipino farmers to establish the smallest practicable unit mill, and the question arises if it would not be possible to establish small incomplete mills that can make the best grade of sugar, although with relatively low per cent extraction. This seems feasible with the present high price of sugar. The problem has been studied by us, and a small experimental mill has just been completed. A description of this mill and the results of tests with it, will soon be published.

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A REVIEW OF THE MAIZE INVESTIGATIONS AT THE COLLEGE OF AGRICULTURE[1]

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This report contains a compilation of the results of investigation on maize, or Indian corn (*Zea mays*),[2] carried out at the College of Agriculture, together with some projects on maize in progress or about to be taken up.

Dr. Mendiola ([13]), after making field investigations on the origin of the corn ear, concluded that the development of the spike into the cob and the ear proper, the shortening of the branch bearing the spike, and the development of the sheaths into the ear husks, and the suppression of the leaf blades, constitute at least three processes involved in the evolution of the corn ear.

Mendiola ([5]) also carried out experiments on, first, what results are obtained from planting different varieties of corn side by side and, second, whether the resulting corn obtained from hybridization might be superior in yield to either parent. Mendiola found that by planting different strains of maize near one another he might produce new strains that are superior in yield and in other physical characters in the F-generation to either parent or to xenia products. He also found that crossing widely separated varieties or strains with the same general type is beneficial in that not only is a more vigorous race produced, but there is a chance also for more combinations of good qualities.

Marquez ([1]) also worked on the hybridization of maize; he tried to determine the best way of obtaining a uniformly colored cross and a more uniform seed strain that would bring a higher price because of uniformity together with improvements produced from cross-fertilization. For this purpose, Marquez made some crosses between strains of certain types such as dent with dent and flint with flint, and arrived at the conclusions, first, that considerable gain is possible in first-generation crosses of closely related strains, and, second, that the hybrid seed may be of great value for commercial planting if closely related strains are used, and, third, that undesirable xenia effects are the usual results of wide crossing of maize.

Besides work on the hybridization, few other experiments with maize have been undertaken at the College during the last few years. Among these was an important piece of work on acclimatization carried out by Mr. Teofilo Nisce ([14]) in the field. The specific objects were to determine, first, which varieties may be adapted to our College Farm conditions; second, in which season of the year the promising varieties grow best; and, third, whether it is possible to secure seeds of the prom-

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[1] Experiment Station contribution, No. 30.

[2] "*Corn.*—(Anglo-Saxon *corn.*)—A small hard particle; a grain.—Collectively, the seeds of any of the cereal grasses used for food; grain, as wheat, rye, barley, oats, maize, etc. Corn is often specifically used for the important cereal crop of a given region; thus in England it is so used of wheat, and in Scotland and Ireland of oats; and in the United States the word is restricted to *Zea mays*, Indian corn, or maize, the other cereals being there collectively called grain. *Maize.*—(From Spanish maiz, from mayz, native name in the West Indies.) Indian corn. A native North American cereal grass (*Zea mays*), cultivated since the discovery of the continent, and now affording one of the most important commercial grain crops. In the United States it is universally called *corn.*—'The ripened ears of this plant; also the seeds, or the meal into which they are ground."—It will be seen from these definitions that *maize, Indian corn,* or *corn* may be used as common names; but it seems best to use *maize.*—Ed.

ising varieties for selection work—the principal criterion for the selection of the seeds being the productiveness. Nisce found that during the first year certain varieties of maize (White Pearl, Kansas Sun-flower, Mosby, Henry Grady, Jackson Red Cob, Hickory King, Hildreth, Freeds White Dent, Reids Yellow Dent Malboro Prolific, Malboro Zears, Shaw's Improved, Alexander's Prolific, Florida Flint, Experiment Station Yellow, Hastings Prolific, Boone Co. White) that came from the United States, were more productive during the dry season, but that they became more productive in the rainy seasons of the following two years. He found further that after gradual acclimatization some of the varieties from the United States appeared to be more productive than the native ones tested—Bolero, Calumpus, and Mismis. Of all the varieties tested, Hildreth gave the highest yield, in grain in its third generation for the rainy season, yielding 5,000 kilograms of unshelled grain per hectare. This record is said not to have been attained by any native variety. Moreover, in the third generation, the foreign varieties, Kansas Sunflower and the Malboro produced 3570 and 3560 kilograms of unshelled grain per hectare, respectively. Nisce also found that: at the beginning of his field tests the three native varieties that were already in their F_2-generation in the College were the highest yielders; all of the varieties grew in the rainy as well as in the dry seasons, but after further acclimatization they became more productive during the rainy season than during the dry season; there was an apparent higher percentage of bearing plants during the rainy season than during the dry season, and this increased productiveness during the rainy season was accompanied by a corresponding decrease in the number of barren plants produced; and, while the length of the growing season had no direct relation to the yield of grain, the highest yields were obtained usually from varieties that mature late.

After knowing the most suitable set of climatic conditions for certain varieties of maize, it is important to study different varieties of corn with reference to the source of the seeds and distancing in the field. This piece of work was undertaken by Macasaet (3), who grew pedigreed seeds of maize obtained from a number of different places in the Philippine Islands. The cultures were carried out simultaneously on the College Farm at Los Baños, and from the results obtained, Macasaet reached the following conclusions: First, in the Yellow Flint, which is the variety most commonly grown in the Philippines, the late-maturing strains (those which mature in about 100 days) are the heavy yielders. Second, the tall strains are more productive than the dwarf ones. Third, the early-maturing strains mature in about 90 days and attain a height of from 200 to 250 centimeters; these are not recommended for field cultures. Fourth, seed corn should be well adapted to the seasonal and soil conditions of the locality where it is to be planted and should be grown in that immediate region. Fifth, too thick planting results in an increase in the total weight of stover at the expense of the ears; too thin planting, on the other hand, decreases the total weight of both stover and ear. Sixth, with C. A. 5917 Yellow Flint Corn and similar dwarf strains of the Native Yellow Flint, the planting distance that gives the best results is 50 centimeters × 50 centimeters; with greater distances apart the total weight of stover and ears is decreased. Planting in rows 80 centimeters apart with one plant at every 25 centimeters gives better yield than when two plants are planted to a hill at distances 80 centimeters between rows and 80 centimeters in the rows; with four plants the total weight of

ears per hectare is more than with two plants per hill at distance 80 centimeters × 80 centimeters, but the average weight per ear of the former is very much less than that of the latter.

The growing of maize together with other crops has been studied to a limited extent at the College. Mr. José P. Esguerra[12] studied experimentally the validity of the common belief that the mixed cropping of maize and rice is more productive than the single cropping. Esguerra grew the plants in field plots, and calculated his results in terms of money value. He found that the total expense in growing maize and rice together amounted to ₱106.43 per hectare, with a profit of ₱43.40. The expense in growing rice alone was ₱140.15 per hectare, or a loss of ₱86.52, while the expense in growing corn alone amounted to ₱65.79 per hectare, or a gain of ₱26.37. In this experiment it appeared that the intercropping of rice and maize was more profitable than the growing either of rice or of maize alone.

Bautista [1] undertook to determine the effect on the production of grain and stalks of maize by intercropping with various legumes. He also tried to determine the effect of legumes upon a succeeding crop of maize, and the difference between the wet-season and the dry-season plantings. Bautista reached the following conclusions: First, legumes had only a remote beneficial effect, if any, on either stalk or shelled-grain production in his tests. Second, when a legume (mongo, cowpeas, etc.) was intercropped with maize the value of the legume crop usually more than counterbalanced the decrease in production of the maize; the growing of legumes side by side with maize was more advantageous than growing maize alone (but maize should not be intercropped with legumes solely for the purpose of furnishing the maize with nitrogeneous fertilizer). Third, cowpeas seemed to be better soil renovators and weed controllers than the other legumes tested.

Still another piece of work undertaken at this College was on maize and its relation to other crops. Mr. Antonio Chanco [11], continuing Francisco's[12a] work on crop rotation, followed the scheme adopted by the latter with the hope of obtaining more reliable and more conclusive results. Chanco found that when maize and sugar cane were grown alternately in the same field for a number of years the result was a gradual decrease in yield of both crops. A greater decrease in yield was obtained when maize was grown continuously on the same plot. When maize and rice were grown alternately in the same field poor results were obtained. When either maize or rice was grown continuously in the same field poorer results were obtained than when the two crops were grown alternately. When cowpeas were grown in rotation with other crops, and the vines plowed under, rapid deterioration of the soil was prevented and the yield of crops was maintained within relatively normal limits. The growing of camotes and corn alternately in the same field was found favorable to both crops.

Studies have also been made on the manurial and commercial fertilizer requirements of maize. Navarro [7] carried out a series of pot cultures with the object of obtaining suggestions as to possible improvements in field practice in connection with cogon lands. Navarro used maize plants as the living indicators for these experiments, and employed as culture media four pots of soil as control, eight pots for an ammonia-leached series, eight pots for a water—leached series, eight pots for a burnt series, seven pots for a normal fertilized series, and three pots for metallic stimulants. To these pots of soil the following chemicals were added as fertilizers, alone or in combination: potassium nitrate, di-calcium phos-

phate, and magnesium sulphate. The cultures were watered with rain water. From the results obtained Navarro arrived at the following conclusions: First, the application of lime to cogon soil was decidedly beneficial. Second, the cogon soil used was found to be deficient in nitrogen in any form. Third, the application of manure from the stable or from the silk-worm house resulted in a more vigorous growth of the maize plant. Fourth, the sterilization of the soil proved to be beneficial to the maize plant.

A somewhat similar piece of work was carried out by Camus (2), who employed a series of cultures with maize plants in plots, with the object of determining the influence of plowing under of leguminous crops, carabao manure, and ashes, and their different combinations, on the growth and production of maize in an "average" Philippine soil. Camus recommends the practice of the plowing under of leguminous crops and the application of fertilizers on corn lands. He said that although the application of carabao manure, ashes, etc., and the plowing under of some legumes on corn land increased the expenses somewhat, yet the yield was also increased—sometimes more than 100 per cent. Camus states, also, that carabao manure, and ashes, and their combinations, are some of the commonest and cheapest fertilizers that can be used. He recommends the use of an equal proportion of carabao manure and ashes at the rate of 20 cubic meters of the mixture per hectare, applying the mixture in furrows rather than broadcasting it. He also states that the application of lime in combination with carabao manure or legumes neutralized the acidity produced by the decomposition of the organic matter in the soil.

Vibar (9) carried out some plot tests with maize supplied with kainit, tankage, and basic slag. One plot received only one of the three fertilizers used; other plots received an application of a combination of two or three of the fertilizers in question, while two control plots received no fertilizer. Vibar states that this set of experiments was undertaken during an exceptionally dry season, and the yield was estimated by him to be only about 80 per cent of what it should be under favorable conditions. Based on the weights of the ears obtained, the kainit proved best, basic slag, next, and tankage third. "The application of kainit gave an increase of 85.04 kilograms of husked grain per hectare (estimated from the yield obtained from 500 square meters.) The application of basic slag or tankage, alone, tended to decrease the production slightly. Vibar states further that the application of two single fertilizers combined, ranked, from best to poorest, in this order: tankage with basic slag, tankage with kainit, and kainit with basic slag. Tankage with basic slag increased the yield in husked ear of maize 297.66 kilograms per hectare (estimated). Tankage with kainit increased the yield in husked grain 281.04 kilograms to the hectare (estimated). The combination of the three single fertilizers showed the greatest effect, an increase of 475.86 kilograms of husked ear of maize per hectare (estimated).

Another piece of work dealing with the fertilizer requirements of maize was carried out by Montellano (6), who grew the plants in plots to which were applied different forms of commercal fertilizers. His results showed that the use of moderate amounts of double or single superphosphate was profitable on soil that had never received any application of fertilizer, but that had been planted previously with some other field crop. Under the conditions of the experiments the application of large amounts of commercial nitrogenous fertilizers was found not to be

profitable. For heavy soil an application of 500 to 1500 kilograms of lime per hectare (broadcasted) was profitable. The combinations of nitrogen, phosphorus, and potassium fertilizers promoted the growth in height of maize. Nitrogen alone invigorated the plants, causing the development of large dark green leaves and heavy stalks. Potassium seemed to affect the development of all the parts of the plant.

Rundles ([8]) made the first attempt at the College to prepare directions for the study of maize in the laboratory and in the field. This study included directions for judging ears of maize; and an appropriate score-card was prepared. Rundles also wrote directions to be used in the selection of maize varieties, including such things as the so-called "Ear-to-row-method", and the de-tasseling of the plants.[3]

The foregoing discussions are based only on the results already obtained from investigations with maize at the College of Agriculture. Other pieces of work are in progress. Of a recent report of Dr. N. B. Mendiola to the chief of the department of agronomy, the following is an abstract:

Preliminary experiments in the production of pure lines in maize are being undertaken by Aniano Elayda ([16]); these may require five or more years for completion. A new method of maize breeding is being tried by several experiment stations; this method takes advantage of the fact that first generation hybrids have in many cases been found to be more productive than their parents. The greatest weakness of the method is that it involves inbreeding of maize, and to remedy this defect it is necessary that highly inbred strains or pure lines be utilized. Hence, the necessity of starting the production of pure lines of maize.

The ear-remnant method of maize yield improvement is being studied by Ambrosio Lontok ([19]). This project may involve two years. The object of the work is to test the method under Philippine conditions and with Philippine material, and to determine whether some simple method of maize yield improvement can not be found for general recommendation to the Philippine farmers.

The relation of external characters of maize to yield is being investigated by Severo Mariano ([20]). This may be conducted through several years. While it has been found in the United States that there is no correlation between yield and external characters of maize ear, it is necessary that experiments along this line be conducted in the Philippines. Here, we had, up to very recently, thought the grains from the tip and butt of a maize ear inferior as seed to the grains from the middle. It would appear that there is no foundation for this belief.

Comparative tests of different varieties of maize are being studied by Emilio Morada ([21]) While it is true that the Agronomy Department possesses a large number of data on the yield of different varietes of maize grown at the College, it is still necessary that the above project be undertaken, because the data we have are of little value for purposes of comparison in yield of different maize varieties.

Acclimatization of native and foreign varieties of maize was investigated by Teofilo Nisce last year, and is being continued by Anastacio Limbo ([18]) this year. This project is a permanent one. As a result of last year's work, it was found that several foreign varieties promise to compare favorably with the Native Yellow Flint and Mexican June varieties.

A study of heredity and selection in maize is being made by Melquiades Pugeda ([22]). The main question in this work is to decide whether or not the length of the prolongation of the husk of maize as well as other characters is hereditary, and to make selection for strains having long prolongations with a view of isolating strains resistant to ear worm and to corn weevil. Several years will be required for this project.

In the case of abnormal ear of maize, it is of scientific as well as of practical interest to decide how far abnormality is hereditary, how far it is not, and what relation abnormality has to yield. As a preliminary step in this direction eight acclimatization plots were planted to maize last year and a few interesting results have already been obtained from this experiment.

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3 The work of Sabado ([15]) on corn has not been included here, because it was never completed. And the complete manuscript of the thesis of V. Aldaba ([10]) can not be located, hence a review of this paper cannot be included in this compilation.

The availability of a large number of different varieties and types of maize is prerequisite to many important phases of maize breeding. Recognizing this fact, we have started the work of isolating new types or varieties as fast as they are found and of purifying those that are already isolated. Thus, in the last maize season a number of newly colored varieties were discovered in a plot belonging to a private grower in Los Baños. The chief work in maize breeding will be selection. Selection for strains resistant to downy mildew of maize is one of our principal concerns. During the last season we observed in a rough way the comparative resistance of the varieties—Davao Early Sweet Flint, Guam White Flint, and Lamao White Moro. We found that Guam White Flint was worse attacked by the downy mildew than either of the two varieties. In the field of the Guam White Flint a number of plants that were apparently resistant were tagged, and ears from them were harvested. The seed will be planted for trials and for further study. An experiment was started with the object of determining the comparative resistance of nearly all of the different maize varieties of which we had seed.

The chief effort in work on maize will be in the direction of isolating high yielding strains of the Native Yellow Flint variety. As a beginning, we gathered from different sources last year nearly fifteen hundred ears. Had we acquired the new land for the Experiment Station, we would have planted these seeds for ear-to-row tests. This planting would have required more than ten hectares of land. The ground not being available, we have given out a part of these valuable seeds to thesis students, and quite a number of ears were sent to Mr. José Zamora in Silang, Cavite.

From the foregoing review of the work on maize that has been done at this College, the following summary may be made: (1) The formation of the maize ear is the final product of evolutionary changes that have taken place in the spike, in the stem of the spike, and in the leaf sheath and blade. (2) The crossing of widely separated varieties produced a very vigorous race. There is, however, a danger of obtaining undesirable xenia effects. (3) A considerable gain was obtained in the first generation crosses of closely related strains. (4) Rainy-season planting of maize was more productive than the dry-season planting. (5) Some varieties of maize from the United States, after gradual acclimatization, were more productive than the native ones. The maize variety Hildreth gave the highest yield in grain in its third generation (5000 kilograms per hectare). (6) The highest yields of grain were usually obtained from varieties that matured late. Conversely, the early varieties were usually poor yielders of grain. (7) Of the native varieties, the Yellow Flint is the most commonly grown in the Philippines and is a rather heavy yielder. It matures in about 100 days. (8) The tall strains (250 to 300 centimeters) have proved more productive than the dwarf ones. (9) Very thick planting increased the production of stover at the expense of the ears. On the other hand, very thin planting decreased the total weight of both stover and ear. (10) The planting distance best for low-growing strains of the Native Yellow Flint was found to be 50×50 centimeters. (11) Rice and maize grown side by side in the same field were found more profitable than either rice or maize grown alone. (12) Legumes had only a remote beneficial effect, if any, on either stalk or shelled grain production; the legume should not be intercropped with maize solely for the purpose of furnishing the maize with nitrogenous fertilizer. (13) The application of lime to cogon soil where maize was to be grown was beneficial to the maize. (14) An equal proportion of carabao manure and ashes at the rate of 20 cubic meters of the mixture was found to be beneficial application to maize land on the College Farm. (15) When maize and rice, or maize and sugar cane, were grown alternately in the same field poor results were obtained. (16) The application of manure from the stable or from the silk-worm house gave a more vigorous growth of the maize plant. (17) Leguminous crops should be plowed under for the maize plant.

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COLLEGE AND ALUMNI NOTES

Mr. Paul M. Wiswall, formerly a Captain in the Chemical Warfare Service, U. S. A., and now working with the National Carbon Co., visited the College on January 13. Mr. Wiswall is on a tour of the world looking up coconut products, principally coconut oil and copra, for one of the large vegetable oil concerns in the United States. He is also studying sugar, largely from the refining standpoint. He is a graduate of the Massachusetts Institute of Technology, commonly called "Boston Tech", where Dr. Roxas took some of his advanced work.

On January 10, a party of Legislators, including De Jesus, G. Pablo, Cecilio, Urguiola, Evangelista, J. C. Santos, Mendiola, Obias, Hernandez, and Kungleon, visited the College to inspect the different laboratories and the farm and to investigate certain needs of the College. The distinguished visitors were received by Professors Elayda, Roxas, Gonzalez, and Espino.

Professor Yule has recently written a very interesting article, entitled *Some superstitions and customs of Filipino farmers*, which has appeared in the Journal of International Relations (continuing the Journal of Race Development.) [1] The editors of that journal made the following comments:

> *Emma Sarepta Yule* is on the faculty of the College of Agriculture, the University of the Philippines, Los Baños, Philippines. In the study of international relations it is well to know the character of the people of the various countries concerned. Miss Yule has given an unusual and valuable paper describing at first hand the customs, traits and characteristics of the Filipino farmer.

The class in Animal Husbandry made a trip to Lipa, Batangas, on January 19, for the purpose of attending the Horse Show there, and to study good types of native horses.

A short, but valuable, article, *The gestation of the carabao*, by Professor Gonzalez, has appeared in the Journal of Heredity.[2] The gestation of the carabao was found to be approximately 320 days (forty days more than the cow and twenty days less than the mare).

José Trinidad, '16, visited the College on January 12. He conferred with Professor Elayda regarding farm management statistics. Mr. Trinidad is temporarily stationed in the central office of the Bureau of Agriculture, Manila.

Mrs. Percy L. Bryant, of Shanghai, was a visitor at the College on January 19.

The class in Agronomy II, accompanied by Dr. Espino and Mr. Vista, visited the coconut plantations of Lucena, Sariaya, San Pablo, Santa Cruz, Pagsanjan, Magdalena, Lilio, Nagcarlang, and Rizal, and the abaca plantations of Paete during Christmas vacation. The purpose of the trip was to secure data on plantation methods and accounting, practiced in those localities.

Mr. Crispin Villanueva, a senior, in connection with his thesis work at this College, succeeded in producing new strains of cassava by growing from seeds. Plants produced from such seedlings show great variations in characters from the mother plant.

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1 Yule, Emma Sarepta, Some superstitions and customs of Filipino farmers. Journal of International Relations **10**: 223-234. 1919.

2 Gonzalez, B. M., The gestation of the carabao. Journal of Heredity **10**: 374-375. *1 fig.* 1919.

Professor B. M. Gonzalez, for several years business manager of the College Co-operative Store and to whose able management the store owes much of its success, has resigned. Dr. R. B. Espino succeeds him as manager.

Mr. C. B. Rouse, General Secretary, Army and Navy Y. M. C. A., and a small party visited the different departments of the College on January 15.

Mr. Jacob J. Wodrazka was appointed recently as Assistant Professor of Modern Languages, effective April 1, 1920.

The following promotions in title, with salary increases, are effective on January 1, 1920: Inocencio Elayda, from Associate Professor to Professor of Agronomy; Bienvenido M. Gonzalez from Associate Professor to Professor of Animal Husbandry, Manuel L. Roxas from Associate Professor to Professor of Chemistry; Otto A Reinking from Associate Professor to Professor of Plant Pathology; Fred W. Ashton from Associate Professor to Professor of Chemistry; Forman T. McLean from Associate Professor to Professor of Botany; Emma S. Yule from fAssistant Professor to Associate Professor of English; Rafael B. Espino from Instructor to Assistant Professor of Agronomy; Gerardo O. Ocfemia from Assistant to Instructor in Plant Pathology; Elias Pañganiban, from Assistant to Instructor in Chemistry; Eduardo Quisumbing, from Assistant to Instructor in Plant Physiology; Jose Esguerra from Assistant in Animal Husbandry to Junior Husbandman. Salary increases are effective for: Evett D. Hester, Associate Professor of Economics; Sam F. Trelease, Associate Professor of Plant Physiology-Nemesio B. Mendiola, Assistant Professor of Agronomy; and Charlotte R. Gillis-Assistant Professor of English; Toribio Vibar, Instructor in Agronomy; Pedro Clariza, Assistant in Mathematics. The following employees of the College received increase in salary: Elias Manalang, Property, Collecting and Disbursing Officer; Joaquin Ruiz de Arana, Farm Engineer; Alfredo V. Yñiguez, Chief Clerk.

Mr. Eduardo Quisumbing, '18, Instructor in Plant Physiology, was married to Miss Basilisa Lim, sister to Captain Vicente Lim, Philippine Scouts, on December 27.

Mr. Exequiel Alcasid, '19, married Miss Florencia Vizconde, a teacher in Rizal Memorial School of Calamba, on December 27. The bridegroom is an employee of the Bureau of Agriculture. Mrs. Alcasid will continue teaching.

Mr. Juan Torres, '19, Assistant in Economics, was married to Miss Aurelia Panopio on January 5. Both are from Santo Tomas, Batangas.

On January 24 the "Lilliputian Sugar Central" of the College started operation. Dr. Roxas is in charge of the sugar course.

The medical department of the College has acquired the services of Mr. Felix Valera, '19, a graduate nurse of the Philippine General Hospital. He reported or duty on November 28, 1919.

IN MEMORIAM

PEDRO M. LAYOSA

BACHELOR OF AGRICULTURE
UNIVERSITY OF THE PHILIPPINES, 1918

AGRICULTURAL INSPECTOR
BUREAU OF AGRICULTURE

BORN AT LIAN, BATANGAS, JANUARY 18, 1898

DIED AT THE PHILIPPINE GENERAL HOSPITAL,

JANUARY 3, 1920

UNIVERSITY OF THE PHILIPPINES

COLLEGE OF AGRICULTURE

LOS BAÑOS

The College of Agriculture is in its eleventh year, with a student body of 444. It occupies a tract of about three hundred and sixty hectares on which every important crop in the Philippines is under cultivation. It has a large series of varieties of leading crops and very numerous introduced plants under tests and observation. The number of distinct cultures, not including series of fertilizer experiments, is more than two thousand. The College has fourteen concrete buildings and several of mixed materials.

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A four-year course based on the completion of the public high school course, and leading to the degree of Bachelor of Science in Agriculture.

Graduate work leading to the degree of Master of Science is given to persons holding the degree of Bachelor of Science.

Tuition for non-residents of the Philippines is ₱150.00 a year.

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For further information address the Dean of the College.

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